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Video Camera

BACKGROUND OF THE INVENTION

Field of the Invention

5 The present invention relates to a video camera
for converting an object image imaged by a
photographing optical system into an electrical signal
using photoelectric conversion means.

Description of the Related Art

10 In recent years, a video camera for converting an
object image imaged by a photographing optical system
into an electrical signal using a photoelectric
conversion element such as a solid-stage image pickup
element, e.g., a CCD (charge coupled device), and
15 recording the electrical signal onto a recording medium
such as a magnetic tape has become popular. *In view of*
ease in use, video cameras are required to have compact
structures, and compact video cameras have been
developed by means of high-density electrical circuit
20 packages, compact CCDs, compact photographing optical
systems, and the like. At the present time, extensive
studies continue to be made to realize further compact
video cameras. For this reason, a further compact
photographing optical system is *desirable*
development of required.

25 The amount of light incident on an image pickup
unit of a video camera is adjusted as follows. That
is, an iris, which can mechanically adjust its aperture

1 size, is arranged in a photographing optical system,
and the aperture size of the iris is adjusted.

However, since such a mechanical iris unit has a
large driving motor unit, it is large in comparison to
5 a photographing optical system lens barrel with a
compact CCD. *This frustrates the*
~~A problem associated with a compact iris~~
~~unit disturbs~~ realization of a compact photographing
optical system lens barrel.

It has been proposed that a material element such
10 as a liquid crystal element, an EC (electrochromic)
element, or the like ~~is~~ *be* used as an iris or a variable
ND (neutral density) filter in place of the mechanical
iris unit. However, these material elements still
suffer from problems associated with wavelength
15 dependency (spectral transmission factor) of a
transmission factor, a small light transmission factor
in a complete transmission state, a very narrow
transmission factor adjustment range as compared to the
above-mentioned mechanical iris, and the like. For
20 these reasons, the material element has not yet been
put into practical applications as an iris or a
variable ND filter for ~~the~~ *a* photographing optical
system.

SUMMARY OF THE INVENTION

a
25 The present invention has been made in
consideration of the above situation, and has as its

1 object to provide a compact video camera by making a
photographing optical system lens barrel compact.

It is another object of the present invention to
solve various problems posed upon adjustment of the
5 incident light amount using a material element.

In order to achieve the above objects, according
to a preferred embodiment of the present invention,
there is disclosed a video camera comprising: a
material element, arranged in a photographing optical
10 system, for controlling a light transmission factor or
a light transmission amount; photoelectric conversion
means for receiving an optical image transmitted
through the material element at a position of an
imaging plane, and converting the optical image into an
15 electrical image signal; and correction means for
correcting light transmission factor wavelength
dependency of the material element in accordance with
light transmission factor characteristics or light
transmission amount characteristics of the material
20 element.

According to the embodiment of the present
invention, there is disclosed a video camera, wherein
the correction means adjusts a correction amount of the
light transmission factor wavelength dependency in
25 accordance with the light transmission factor or the
light transmission amount of the material element.

1 According to the embodiment of the present
invention, there is disclosed a video camera, wherein
the correction of ^{by} the correction means is achieved by
auto white-balance control for an output signal from
5 the photoelectric conversion means.

 According to the embodiment of the present
invention, there is disclosed a video camera, wherein
the correction of ^{by} the correction means is achieved by
changing a sensitivity of the photoelectric conversion
10 means in accordance with a light wavelength.

 According to the embodiment of the present
invention, there is disclosed a video camera, wherein
the correction of ^{by} the correction means is achieved by a
filter provided to the photographing optical system or
15 the photoelectric conversion means.

 According to the embodiment of the present
invention, there is disclosed a video camera, wherein
the correction of ^{by} the correction means is achieved by
arranging another material element capable of
20 controlling a light transmission factor in the
photographing optical system.

 According to the embodiment of the present
invention, there is disclosed a video camera, wherein
the correction means comprises storage means for
25 storing the light transmission factor wavelength
dependency of the material element or the correction

1 amount of the light transmission factor wavelength
dependency of the material element.

According to the embodiment of the present
invention, there is disclosed a video camera, wherein
5 the storage means stores a plurality of light
transmission factor wavelength dependencies or a
plurality of correction amounts in accordance with the
light transmission factor or the light transmission
amount of the material element.

10 In order to achieve the above objects, according
to another preferred embodiment of the present
invention, there is disclosed a video camera
comprising: a material element, arranged in a
photographing optical system, for controlling a light
15 transmission factor or a light transmission amount;
photoelectric conversion means for receiving an optical
image transmitted through the material element at a
position of an imaging plane, converting the optical
image into an electrical image signal, and capable of
20 adjusting at least one of a light accumulation time and
a sensitivity; and exposure amount adjustment means for
adjusting the light transmission factor or the light
transmission amount of the material element, and at
least one of the light accumulation time and the
25 sensitivity of the photoelectric conversion means.

According to the embodiment of the present
invention, there is disclosed a video camera, wherein

1 the exposure amount adjustment means electrically
adjusts the light transmission factor or the light
transmission amount of the material element.

According to the embodiment of the present
5 invention, there is disclosed a video camera, wherein
the exposure amount adjustment means adjusts the light
transmission factor or the light transmission amount of
the material element in accordance with incident light.

According to the embodiment of the present
10 invention, there is disclosed a video camera, wherein
the exposure amount adjustment means comprises storage
means for storing at least one relationship between the
light transmission factor or the light transmission
amount of the material element and the light
15 accumulation time or the sensitivity of the
photoelectric conversion means.

It is still another object of the present
invention to provide a compact video camera by making a
photographing optical system lens barrel compact.

20 It is still another object of the present
invention to provide a video camera, which can fully
exhibit the performance of an iris adopting a material
element which is arranged in a video camera.

Other objects and features of the present
25 invention will become apparent from the following
specification and the accompanying drawings.

1 BRIEF DESCRIPTION OF THE DRAWINGS

 Fig. 1 is a schematic sectional view showing an internal arrangement of a video camera according to the first embodiment of the present invention;

5 Fig. 2 is a block diagram showing a circuit arrangement according to the first embodiment of the present invention;

 Fig. 3 is a graph showing an example of the light transmission factor wavelength dependency characteristics of a material element shown in Fig. 1;

 Fig. 4 is a flow chart showing a control operation sequence according to the first embodiment of the present invention;

15 Fig. 5 is a block diagram showing a light transmission factor wavelength dependency correction circuit using a white-balance circuit according to the first embodiment of the present invention;

 Fig. 6 is a block diagram showing a correction circuit for correcting the light transmittance factor wavelength dependency of a material element due to a change in temperature according to the second embodiment of the present invention;

20 Fig. 7 is an explanatory view showing a color filter arrangement of a color filter of an image pickup element shown in Fig. 1;

 Fig. 8 is a graph showing the light transmission factor wavelength dependency characteristics of another

1 material element or a filter in the fourth embodiment
of the present invention;

Fig. 9 is a schematic sectional view showing an
internal arrangement of a video camera according to a
5 modification of the fourth embodiment of the present
invention;

Fig. 10 is a graph showing another example of the
light transmission factor wavelength dependency
characteristics of a material element which can be
10 applied to the first embodiment of the present
invention;

Fig. 11 is a schematic sectional view showing an
internal arrangement of a video camera according to the
fifth embodiment of the present invention;

15 Fig. 12 is a block diagram showing a circuit
arrangement according to the fifth embodiment of the
present invention;

Fig. 13 is a graph showing a program line for
exposure amount control in the fifth embodiment of the
20 present invention;

Fig. 14 is comprised of Figs. 14A and 14B are flow
charts showing a control sequence of exposure amount
control in the fifth embodiment of the present invention;

Fig. 15 is a block diagram showing a video camera
25 according to the sixth embodiment of the present
invention;

1 Fig. 16 is a block diagram showing a video camera
according to the seventh embodiment of the present
invention;

 Fig. 17 is a block diagram showing a video camera
5 according to the eighth embodiment of the present
invention;

 Fig. 18 is a block diagram showing a video camera
according to the ninth embodiment of the present
invention;

10 Fig. 19 is a block diagram showing a video camera
according to the 10th embodiment of the present
invention;

 Fig. 20 is a block diagram showing a video camera
according to the 11th embodiment of the present
15 invention;

 Fig. 21 is a block diagram showing a video camera
according to the 12th embodiment of the present
invention;

 Fig. 22 is a block diagram showing a circuit
20 arrangement in the 12th embodiment of the present
invention;

 Fig. 23 is a flow chart for controlling an
operation of the 12th embodiment of the present
invention;

25 Fig. 24 is a block diagram showing a video camera
according to the 13th embodiment of the present
invention;

1 Fig. 25 is a block diagram showing a circuit
arrangement in the 13th embodiment of the present
invention;

 Fig. 26 is a block diagram showing the 14th
5 embodiment of the present invention;

 Fig. 27 is a block diagram showing the 15th
embodiment of the present invention;

 Fig. 28 is a graph showing an example of the
spectral transmission characteristics of a near
10 infrared light cut filter according to the 16th
embodiment of the present invention;

 Fig. 29 is a graph showing the spectral
transmission characteristics of a material element
according to the 16th embodiment of the present
15 invention;

 Fig. 30 is a graph showing the spectral
transmission characteristics of the material element
according to the 16th embodiment of the present
invention;

20 Fig. 31 is a view showing an arrangement of the
material element integrated with the near infrared
light cut filter according to the 16th embodiment of
the present invention;

 Fig. 32 is a view showing another arrangement of
25 the material element integrated with the near infrared
light cut filter according to the 16th embodiment of
the present invention;

1 Fig. 33 is a view showing still another
arrangement of the material element integrated with the
near infrared light cut filter according to the 16th
embodiment of the present invention;

5 Fig. 34 is a view showing still another
arrangement of the material element integrated with the
near infrared light cut filter according to the 16th
embodiment of the present invention;

10 Fig. 35 is a view showing still another
arrangement of the material element integrated with the
near infrared light cut filter according to the 16th
embodiment of the present invention;

15 Fig. 36 is a block diagram showing a circuit
arrangement according to the 17th embodiment of the
present invention;

 Fig. 37 is a graph showing the light transmission
factor wavelength dependency characteristics of a
material element;

20 Fig. 38 is a graph showing the light transmission
factor wavelength dependency characteristics of the
material element in accordance with a change in
temperature;

25 Fig. 39 is a schematic sectional view showing a
video camera according to the 18th embodiment of the
present invention;

1 Fig. 40 is a block diagram showing a circuit
arrangement according to the 18th embodiment of the
present invention;

 Fig. 41 is comprised of Figs. 41A to 41C are flow
5 charts for controlling the operation of a video camera
according to the 18th embodiment of the present invention;

 Fig. 42 is a schematic sectional view showing a
video camera according to the 19th embodiment of the
present invention;

10 Figs. 43A and 43B are respectively a side view and
a front view showing a material element according to
the 20th embodiment of the present invention;

 Figs. 44A to 44H are views showing a method of
adjusting the transmission factor of the material
15 element;

 Fig. 45 is a side view showing a light amount
adjustment device according to the 21st embodiment of
the present invention;

 Figs. 46A and 46B are respectively a side view and
20 a front view showing a light amount adjustment device
according to the 22nd embodiment of the present
invention;

 Fig. 47 is a schematic sectional view showing main
part of a video camera according to the 23rd embodiment
25 of the present invention;

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1 Fig. 48 is a schematic sectional view showing a
video camera according to the 23rd embodiment of the
present invention;

 Figs. 49A and 49B are flow charts showing an
5 exposure amount control operation in the embodiment
shown in Fig. 48;

 Figs. 50A and 50B are flow charts showing the
second example of the exposure amount control
operation;

10 Fig. 51 is a schematic sectional view showing a
video camera according to the 24th embodiment of the
present invention;

 Figs. 52A and 52B are flow charts showing an
exposure amount control operation in the embodiment
15 shown in Fig. 51;

 Fig. 53 is a flow chart showing the second example
of exposure amount control processing corresponding to
the embodiment shown in Fig. 51;

 Figs. 54A and 54B are flow charts showing the
20 third example of exposure amount control processing
corresponding to the embodiment shown in Fig. 51;

 Fig. 55 is a front view showing an arrangement of
a material element used in the 23rd and 24th
embodiments; and

25 Figs. 56A to 56H are explanatory views showing a
method of adjusting the transmission factor of the
material element shown in Fig. 55.

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1 DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

 The preferred embodiments of the present invention will be described in detail hereinafter with reference to the accompanying drawings.

5 (First Embodiment)

 Fig. 1 shows a schematic arrangement of an internal mechanism of a video camera according to the first embodiment of the present invention, Fig. 2 shows a circuit arrangement of this embodiment, and Fig. 3 shows the light transmission factor wavelength dependency characteristics of a material element used in this embodiment.

 Referring to Fig. 1, a photographing optical system is constituted by a focus lens 1a for a focusing operation, a zoom lens 1b, and a stationary lens 1c. The focus lens 1a is held by a cylindrical focus lens holding frame 2, which has a gear portion 2a. A cylindrical stationary portion 3 is fixed to a camera body, and is threadably engaged with the focus lens holding frame 2. A cam cylinder 4 has a cam groove for determining the position of the zoom lens 1b, and is rotatably held by the stationary portion 3. The zoom lens 1b is held by lens frames 5 and 6.

 The focus lens holding frame 2 is pivoted by a focus motor 7. A gear 7a is attached to the output shaft of the motor 7, and is meshed with the gear portion 2a of the focus lens holding frame 2. The cam

1 cylinder 4 is pivoted by a zoom motor 8. A gear 8a is
attached to the output shaft of the motor 8, and is
meshed with a gear portion 4a of the cam cylinder 4.

5 A material element 9 serving as an iris consists
of, e.g., a liquid crystal capable of controlling the
light transmission factor. An image pickup element 10
comprises, e.g., a CCD. The photographing optical
system has an optical axis 11.

10 An electronic viewfinder 12 has a lens 13. In
addition to the above arrangement, the camera has a
power switch 14 and a zoom operation unit 15. The
camera also has a camera control circuit 21, and a
recording unit 22 and a power source 23, which are
electrically connected to the camera control circuit.
15 The camera control circuit 21 is also electrically
connected to the focus motor 7, the zoom motor 8, the
material element 9, the image pickup element 10, the
electronic viewfinder 12, the power switch 14, and the
zoom operation unit 15.

20 As shown in Fig. 2, the camera control circuit 21
is connected to a focus control circuit 24, a zoom
control circuit 25, an exposure amount control circuit
26, an image pickup element control circuit 27, an
electronic viewfinder control circuit 28, and a
25 recording unit control circuit 29, and is further
connected to a photographing switch 30, a main switch

1 31, and a zoom switch 1 (32) and a zoom switch 2 (33)
constituting the zoom operation unit 15.

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2 The material element 9 shown in Fig. 1 comprises a
liquid crystal element or an electrochromic element,
5 serves as an iris for limiting the incident light
amount, and can electrically control the light
transmission factor or amount. ~~It is ideal that~~ *Ideally,* the
material element 9 has a constant light transmission
factor regardless of the wavelength of incident light.
10 In general, even when the light transmission factor of
the material element is highest, the light transmission
factor changes depending on the wavelength of incident
light, as shown in Fig. 3. Referring to Fig. 3, R
represents a red region, G represents a green region,
15 and B represents a blue region.

For this reason, in this embodiment, in order to
avoid a color balance error of an image caused by the
material element 9, the white balance is corrected
under the control of the camera control circuit 21, as
20 will be described later.

Fig. 4 is a flow chart showing a control operation
to be executed by the camera control circuit 21 of this
embodiment. An operation of the first embodiment of
the present invention will be described below with
25 reference to this flow chart.

When a photographer operates the power switch 14
of the camera to turn on the power source 23, the image

a

1 pickup element 10 is driven (step S1) to move the focus
lens 1a in the optical axis direction, so that the
high-frequency components of a video signal output from
the image pickup element 10 become ^amaximum. In order
5 to move the focus lens 1a, the focus motor 7 is
rotated. The gear 7a attached to the motor output
shaft is meshed with the gear portion 2a of the focus
lens holding frame 2, and the focus lens holding frame
2 is threadably engaged with the stationary portion 3.
10 For this reason, the focus lens 1a is moved in the
direction of the optical axis 11 upon rotation of the
motor 7. A focusing operation is performed by this
lens movement. At the same time, the light
transmission factor of the material element 9 is
15 controlled by the exposure amount control circuit, so
that the amount of light incident on the image pickup
element 10 becomes constant. In this control, as
described above, in order to compensate for a color
balance error caused by a change in light transmission
20 factor depending on the wavelength of incident light,
the white balance is corrected (step S2).

A video signal output from the image pickup
element 10 and subjected to predetermined signal
processing is displayed on the electronic viewfinder
25 12, and can be observed by the photographer (step S3)
(this state will be referred to as a standby state
hereinafter). In this state, when the photographer

1 operates the zoom operation unit 15 (steps S4, S5, and
S7), the zoom motor 8 is rotated (steps S6 and S8).
More specifically, since the gear 8a is meshed with the
gear portion 4a of the cam cylinder 4, the cam cylinder
5 4 is rotated upon rotation of the motor 8, and the zoom
lens 1b is moved along the cam groove of the cam
cylinder 4 in the direction of the optical axis 11,
thus performing a zoom operation. The zoom operation
unit 15 has the zoom switch (1) 32 and the zoom switch
10 (2) 33. When the zoom switch (1) 32 is turned on
(closed) (step S5), the zoom motor 8 is rotated forward
(step S6), and the zoom lens 1a is moved toward the
wide-angle end. On the other hand, when the zoom
switch (2) 33 is turned on (step S7), the zoom motor 8
15 is rotated backward (step S8), and the zoom lens 1b is
moved toward the telephoto end. Note that the zoom
switches 32 and 33 cannot be simultaneously turned on.

When the photographer depresses a photographing
button (not shown) in step S4, the photographing switch
20 30 is turned on. When the camera control circuit 21
confirms that the photographing switch 30 is turned on
(step S4), a photographing (image recording) operation
is started (step S10). Thus, a video signal output
from the image pickup element 10 is transferred to the
25 recording unit 22 via the camera control circuit 21,
and is converted into a signal format suitable for
recording via the recording unit control circuit 29.

1 Thereafter, the converted signal is recorded on a
recording medium such as an 8-mm video tape. At this
time, the above-mentioned focusing operation and
exposure amount adjustment are parallelly executed, and
5 the video signal is displayed on the electronic
viewfinder 12. The zoom operation is also performed
according to an operation of the photographer in the
same manner as described above (steps S11 to S15).
When the photographer releases the photographing button
10 (not shown), the photographing switch 30 is turned off
(open). When the camera control circuit 21 confirms
that the photographing switch 30 is turned off (step
S16), the image recording operation is stopped (step
S17), and the camera returns to the above-mentioned
15 standby state (step S4).

(Second Embodiment)

20 A circuit arrangement for correcting the light
transmission factor wavelength dependency of a material
element using a white-balance adjustment circuit will
be described below.

25 As described above, when the material element is
inserted in the photographing optical path, the color
balance changes depending on the wavelength dependency
of the light transmission factor, and is corrected by a
white-balance adjustment circuit. In this case, if the
wavelength dependency of the light transmission factor
of the material element is always constant, the change

1 in color balance can be reliably corrected by the
operation of the white-balance circuit.

However, when the wavelength dependency of the
light transmission factor of the material element
5 changes depending on the light transmission factor or
temperature, flexible control is required.

Fig. 5 shows a white-balance adjustment circuit
for a case wherein the wavelength dependency of the
light transmission factor of the material element
10 changes depending on the light transmission factor,
i.e., a voltage applied to the material element (in,
e.g., an EC element, the wavelength dependency changes
according to its light transmission factor, i.e., an
applied voltage), and Fig. 6 shows a white-balance
15 adjustment circuit for a case wherein the wavelength
dependency of the light transmission factor of the
material element changes depending on a change in
temperature. These white-balance adjustment circuits
will be described below.

20 Fig. 5 is a block diagram showing an arrangement
of the white-balance adjustment circuit for performing
white-balance adjustment on the basis of an image
pickup signal output from the image pickup element 10.
This circuit is arranged in the camera control circuit
25 21.

Referring to Fig. 5, a light beam transmitted
through the material element as an iris for controlling

1 the incident light amount is incident on the image
pickup element 10, and is photoelectrically converted
into an image pickup signal to be output. Image pickup
signals time-serially output from the image pickup
5 element are sampled and held by sample-hold circuits
34R, 34G, and 34B in accordance with the pixel
arrangements of color filters of the image pickup
element. R, G, and B components extracted by the
sample-hold circuits 34R, 34G, and 34B are respectively
10 smoothed by lowpass filters 35R, 35G, and 35B.

The R, G, and B signals respectively output from
the lowpass filters 35R, 35G, and 35B are subjected to
predetermined signal processing by a matrix circuit 38,
and are respectively output as a luminance signal Y,
15 and color difference signals R-Y and B-Y. These
signals are supplied to a camera process circuit (not
shown).

Multipliers 36R and 36B and gain control
amplifiers 37R and 37B for varying gains are arranged
20 at the output sides of the lowpass filters 35R and 35B.
The R-Y signal and the B-Y signal output from the
matrix circuit 38 are smoothed by lowpass filters 39R
and 39B, and are supplied to differential amplifiers
40R and 40B. The gain control amplifiers 37R and 37B
25 are controlled by the outputs from the differential
amplifiers 40R and 40B, thereby changing gains.

1 In this operation, the gain control amplifiers are
controlled, so that the levels of the R-Y and B-Y
signals become 0, thereby automatically executing
white-balance adjustment.

5 The Y signal is supplied to a drive control
circuit for controlling the transmission factor of the
material element, and the transmission factor of the
material element is controlled, so that an average
value of the levels of the Y signal becomes a
10 predetermined value. This operation itself corresponds
to a so-called auto-iris operation.

15 In the characteristic arrangement of this
embodiment, a correction circuit 41 comprising a
look-up table LUT, which stores the relationship
between the transmission factors of the material
element and the wavelengths, i.e., the transmission
factors corresponding to colors, is arranged. Light
transmission factor information 42a of the material
element 9 is referred to, and correction coefficients
20 according to a change in transmission factor in units
of colors corresponding to the transmission factor are
obtained with reference to the LUT. The correction
coefficients are supplied to the multipliers 36R and
36B, and are multiplied with the R and B signals,
25 thereby canceling a change in wavelength dependency
according to the light transmission factor of the
material element.

a 1 More specifically, ~~when~~^{when} the light transmission factor is changed by changing a voltage to be applied to the material element so as to control the incident light amount, no problem is posed if transmission factors in units of wavelengths, i.e., colors, are balanced. However, in practice, the balance of transmission factors in units of colors changes depending on the light transmission factor, as shown in Fig. 10 (to be described later).

10 If such a change is merely corrected by a normal operation of the white-balance circuit, a change in color balance caused by a change in transmission factor of the material element cannot be discriminated from a change in color balance caused by a change in color temperature of an object field to be photographed while the transmission factor of the material element remains unchanged. Thus, when the color temperature of the object field changes, a wrong color correction is made. For example, even when the color of the object field changes, this change is corrected, and a color different from an actual color is undesirably recorded.

20 In order to solve this problem, in this embodiment, as for wavelength dependency caused by a change in light transmission factor of the material element, the transmission factor dependency characteristics of wavelengths according to the transmission factors of the material element are

1 prestored in the LUT in the form of correction
coefficients, correction coefficients in units of
wavelengths according to the transmission factor of the
material element at that time are read out, and are
5 supplied to the multipliers 36R and 36B. The R and B
signals are respectively multiplied with the readout
correction coefficients to achieve correction, so that
the balance of changes in transmission factors at the
respective wavelengths is left unchanged even when the
10 transmission factor of the material element changes.
More specifically, even when the transmission factor of
the material element changes in Fig. 10, wavelength
dependency characteristics ② can be maintained
constant.

15 With this arrangement, an auto-iris apparatus
using the material element can be realized without
disturbing a normal white-balance operation.

(Third Embodiment)

20 Fig. 6 shows a white-balance adjustment circuit
considering a case wherein the wavelength dependency of
the light transmission factor of the material element
changes depending on a change in temperature. The
arrangement shown in Fig. 6 is basically the same as
that shown in the block diagram of Fig. 5, except that
25 correction coefficients to be supplied to the
multipliers 36R and 36B are those for correcting the
light transmission factor dependency of wavelengths in

1 correspondence with a change in temperature, and are
stored in a coefficient circuit 43 in the form of an
LUT. The correction coefficients are referred to in
accordance with an output from a temperature sensor TE,
5 the correction coefficients corresponding to the
detected temperature are read out from the coefficient
circuit, and are supplied to the multipliers 36R and
36B, thereby correcting a change in color balance
caused by a change in temperature.

10 In this case as well, correction according to a
change in temperature is performed outside a feedback
loop for white-balance control, and temperature
compensation can be performed without influencing a
normal white-balance adjustment operation.

15 (Fourth Embodiment)

In the first and second embodiments described
above, the light transmission factor wavelength
dependency of the material element 9 is corrected by
white-balance adjustment. This correction may be
20 performed using a color filter of the image pickup
element 10 in place of the white-balance adjustment.
Fig. 7 shows an arrangement of the color filter of the
image pickup element 10. This color filter is
constituted by Mg (magenta), Cy (cyan), Ye (yellow),
25 and G (green) filters. When the material element 9 has
the light transmission factor wavelength dependency
shown in Fig. 3, the light transmission factor of a

1 blue region (B) is smaller than those of a red region
(R) and a green region (G), and the light transmission
factors of the red region (R) and the green region (G)
are almost equal to each other.

5 For this reason, when the light transmission
factors of the cyan filter (Cy) and the magenta filter
(Mg) shown in Fig. 7 are set to be larger than those of
the yellow filter (Ye) and the green filter (G), the
light transmission amounts of the respective wavelength
10 regions can be corrected to be almost ^{uniform} ~~uniformed~~ at the
position of the image pickup element 10.

At this time, when the areas of the cyan filter
(Cy) and the magenta filter (Mg) are set to be larger
than those of the yellow filter (Ye) and the green
15 filter (G), the light transmission amounts of the
respective wavelength regions can be corrected as well.

Alternatively, the light transmission factor
wavelength dependency of the material element 9 may be
corrected by changing the sensitivity levels of pixels
20 of the image pickup element 10 corresponding to the
respective filter portions. If the material element
has characteristics different from those shown in
Fig. 3, the light transmission factor wavelength
dependency of the material element 9 can be corrected
25 by adjusting the transmission factors or areas of the
color filter, or the sensitivity levels of the image
pickup element 10.

1 In addition, when the material element 9 has the
characteristics shown in Fig. 3, light transmission
factor wavelength dependency of the material element 9
can be corrected by combining the element 9 with a
5 correction filter 16 or another material element 17
having opposite characteristics shown in Fig. 8. The
correction filter 16 or the other material element 17
may be arranged at a position different from the
material element 9, as shown in Fig. 9, or may be
10 arranged at the same position as the material element
9, or may be arranged together with the image pickup
element 10 or the color filter.

 When the transmission factor of the material
element 9 is decreased, if the light transmission
15 factor wavelength dependency characteristics change, as
shown in, e.g., Fig. 10 (in the case of, e.g., an EC
element), such a change may be corrected by the other
material element 17 described above. Note that a curve
① in Fig. 10 represents characteristics in a maximum
20 transmission state, and a broken curve ② represents
characteristics in a minimum transmission state.

 A storage circuit, which stores the light
transmission factor wavelength dependency of the
material element shown in Fig. 3 or its correction
25 amounts, may be arranged, and the light transmission
factor wavelength dependency of the material element
may be corrected by the above-mentioned method (e.g.,

1 white-balance adjustment) using, e.g., the light
transmission factor or amount of the material element
or the amount of light incident on the photographing
optical system.

5 When the light transmission factor wavelength
dependency of the material element changes depending on
the light transmission factor or amount of the material
element, as shown in Fig. 10, a storage circuit, which
stores a plurality of light transmission wavelength
10 dependency characteristics in respective light
transmission states (states with various light
transmission factors or amounts) or corresponding
correction amounts of the light transmission factor
wavelength dependency characteristics, may be arranged.
15 Thus, the light transmission factor wavelength
dependency of the material element in each light
transmission state may be corrected by the
above-mentioned method (e.g., white-balance adjustment)
using, e.g., the light transmission factor or amount of
20 the material element or the amount of light incident on
the photographing optical system.

As the material element 9 or 17, a material
element whose light transmission factor decreases as
the intensity of incident light increases may be used
25 in place of an element for electrically controlling the
light transmission factor.

1 The above embodiments and their modifications may
be applied not only to a movie video camera but also to
a still video camera.

(Fifth Embodiment)

5 The fifth embodiment of the present invention will
be described below. Fig. 11 shows a schematic
arrangement of an internal mechanism of a video camera
according to the fifth embodiment of the present
invention, and Fig. 12 shows a circuit arrangement of
10 this embodiment. Referring to Fig. 11, the video
camera has a material element 44, and the image pickup
element 10 such as a CCD having a light accumulation
time adjustment function (a so-called shutter
function). The material element 44 is prepared by
15 forming a transient metal oxide film (IrO_x , Ta_2O_5 , WO_3 ,
or the like) on the surface of a glass plate, and can
control the light transmission factor or amount of the
film by applying a voltage to the film. This film is
known to those who are skilled in the art. Referring
20 to Fig. 12, a program storage circuit 45 stores a
program used by the camera control circuit 21. Other
arrangements are the same as those in the first
embodiment of the present invention shown in Figs. 1
and 2, and a detailed description thereof will be
25 omitted.

Fig. 13 shows the content of a control program
stored in the program storage circuit. In order to

1 achieve optimal exposure on the image pickup element
10, the camera control circuit 21 performs control
according to a program line shown in Fig. 13 stored in
the program storage circuit 45. More specifically, the
5 camera control circuit 21 causes the exposure amount
control circuit 26 to control the light transmission
factor or amount of the material element 44, so that
the amount of light to be incident on the image pickup
element 10 becomes constant. When incident light is
10 too strong to control the incident light amount by the
material element alone, the light transmission factor
amount of the material element 44 is set to be a
minimum value, and a high-speed shutter operation is
realized using the shutter function of the image pickup
15 element 10, thus achieving suitable exposure.

The exposure amount control sequence of the image
pickup element 10 will be described below with reference
to the flow charts shown in Figs. 14A and 14B. In a
state wherein the incident light amount is adjusted by
20 the above-mentioned material element 44 (steps S21 and
S22), if the incident light amount increases (step
S23), the camera control circuit 21 applies a voltage
to the material element 44 to decrease the light
transmission factor of the material element 44 (steps
25 S24 and S25). However, when the incident light amount
does not ^{greatly} ~~largely~~ change or when the incident light
amount increases even if the voltage is applied to the

1 material element 44 for a predetermined period of time
(steps S26 to S31), the camera control circuit 21
determines that the incident light amount cannot be
controlled by the material element 44 alone. The
5 camera control circuit 21 increases the shutter speed
using the shutter function of the image pickup element
10 (steps S32 and S33), thus obtaining suitable
exposure (step S34).

(Modification of Fifth Embodiment)

10 In addition, the same effect as that obtained by
adjusting the exposure amount can be obtained by
adjusting the sensitivity of the image pickup element
10 in place of adjusting the light accumulation time of
the image pickup element 10. If a material element
15 whose light transmission factor decreases as the
intensity of incident light increases is used in place
of the material element 44 whose light transmission
factor is controlled by a voltage, the exposure amount
control can be achieved by controlling only the light
20 accumulation time or the sensitivity of the image
pickup element 10, thus simplifying control. With this
arrangement, the exposure amount control circuit 26 and
the program storage circuit 45 can be omitted, and
exposure amount control can be achieved by the image
25 pickup element control circuit 27 alone. As the
material element 44, a material element whose light
transmission factor changes according to both a voltage

1 and incident light intensity may be used or a liquid
crystal element may be used. In addition, the fifth
embodiment of the present invention can be applied not
only to a movie camera but also to a still video
5 camera.

As described above, according to the
above-mentioned embodiments, since the light
transmission factor wavelength dependency of the
material element can be corrected, the material element
10 can be used in place of an iris for mechanically
adjusting an aperture portion of the photographing
optical system. For this reason, since a drive unit
for the iris for mechanically adjusting the aperture
portion can be omitted, a compact photographing optical
15 system lens barrel, i.e., a compact video camera can be
provided.

Similarly, since the exposure amount of the video
camera can be adjusted by the material element and the
electronic shutter function of the image pickup element
20 or sensitivity adjustment of the image pickup element
in place of an iris for mechanically adjusting the
aperture portion of the photographing optical system, a
motor unit for the iris for mechanically adjusting the
aperture portion can be omitted.

25 (Sixth Embodiment)

The sixth embodiment of the present invention will
be described below.

1 In each of the above embodiments, a change in
light transmission factor according to the wavelength
occurring when a material element such as a liquid
crystal or EC element is used as an iris is corrected
5 by white-balance adjustment, a color filter, or the
like. *The* ~~This~~ embodiment to be described below is
achieved to improve an iris function obtained when a
material iris is arranged in a video camera.

10 More specifically, a video camera for converting
an object image imaged by a photographing optical
system into an electrical signal using a photoelectric
conversion element such as a CCD (charge coupled
device), and recording the electrical signal onto a
15 recording medium such as a magnetic tape has become
popular. In view of ease in use, video cameras are
required to have compact structures, and compact video
cameras have been developed by means of high-density
electrical circuit packages, compact CCDs, compact
20 photographing optical systems, and the like. The iris
of such a video camera photographing optical system
adjusts the aperture portion area of the iris by an
aperture blade prepared by adhering an ND filter to a
portion of the aperture portion, and another aperture
blade.

25 In order to meet the demand for a further compact
video camera, the photographing optical system need be
rendered further compact. However, since the

1 above-mentioned mechanical iris unit for adjusting the
aperture area has a large motor unit, it is large in
comparison to a photographing optical system lens
barrel with a compact CCD. A problem associated with a
5 compact iris unit disturbs realization of a compact
photographing optical system lens barrel.

Therefore, attempts have been made to omit a drive
unit for the conventional iris unit and to make the
photographing optical system lens barrel compact by
10 using a material element such as a liquid crystal
element, an EC (electrochromic) element, or the like in
place of the mechanical iris unit. Furthermore, it is
required to make the material element compact, and to
hold the material element in the photographing optical
15 system lens barrel as easily as possible.

On the other hand, the video camera including the
conventional mechanical iris unit suffers from the
following problems.

More specifically, in an optical system having a
20 small full-open aperture size, even if an ND filter is
adhered to an aperture blade, the influence of
diffraction appears near a small aperture state. Also,
in the iris unit in which an ND filter is adhered to a
blade portion, an out-of-focus image by the iris
25 deteriorates.

This embodiment has been made to provide a video
camera which can solve the above-mentioned problems.

1 In this video camera, since a material element capable
of controlling the light transmission factor is
provided to an optical element of a photographing
optical system, no special frame for mounting the
5 material element is required. Therefore, the size of
the video camera can be prevented from being increased.
Both the material element and the conventional
mechanical iris unit are used commonly, thus
eliminating the influence of diffraction.

10 *the* The embodiment of the present invention will be
described below with reference to the accompanying
drawings.

15 Fig. 15 is a schematic view showing an arrangement
of a video camera according to the sixth embodiment of
the present invention.

20 Referring to Fig. 15, a focus lens 1a, a zoom lens
1b, and a stationary lens 1c constitute a photographing
optical system. Note that the same reference numerals
in Fig. 15 denote the same parts as in Fig. 1, and a
detailed description thereof will be omitted. A
material element 9 such as a liquid crystal element
capable of adjusting the transmission light amount is
arranged between a lens, closest to the image pickup
plane side, of the photographing optical system, and
25 the image pickup plane of the image pickup element 10.
If at least one of optical systems arranged adjacent to
the material element is a stationary optical system (in

1 this embodiment, an optical system at the object side
of the material element is the stationary optical
system), the material element 9 can be held by a
holding lens barrel 46 for holding the stationary
5 optical system, i.e., the stationary lens 1c. Thus,
the material element can be easily held. The camera
control circuit is electrically connected to the focus
motor 7, the zoom motor 8, the material element 9, the
image pickup element 10, the electronic viewfinder 12,
10 the power switch 14, and the zoom operation unit 15,
and controls these units. The focus lens 1a receives
an effective light beam 16. Since the circuit
connections of the video camera are the same as those
in Fig. 2, and the operation control of the entire
15 video camera is the same as that shown in the flow
chart of Fig. 4, a detailed description thereof will be
omitted.

In this embodiment, the material element 9 is held
by the holding lens barrel 46 for the stationary lens
20 1c. When the material element is arranged at a
position adjacent to the stationary optical system, it
can be easily held by the holding lens barrel for the
stationary optical system without arranging any special
holding member.

25 Also, when the material element is arranged at a
position adjacent to an optical lowpass filter or an
image pickup element, the material element can be

1 easily held by a holding member for the optical lowpass
filter or the image pickup element.

However, when the material element is arranged
adjacent to, e.g., the stationary optical system, if
5 the material element undesirably becomes large in size,
the material element may be arranged at a position
where its two surfaces are adjacent to movable optical
systems or may be held by a movable optical system
holding lens barrel.

10 (Seventh Embodiment)

Fig. 16 is a schematic sectional view of a video
camera according to the seventh embodiment of the
present invention. The same reference numerals in
Fig. 16 denote the same parts as in Fig. 15, and a
15 detailed description thereof will be omitted. This
embodiment is characterized in that an iris unit 45 for
mechanically changing the aperture area using aperture
blades is arranged in addition to the material element
9 arranged in front of the image pickup element 10.
20 Since this embodiment is arranged to decrease the light
transmission factor of the material element 9 in the
small aperture state of the iris unit 45, an image
pickup operation of a high-luminance object can be
realized without arranging any ND filter to the
25 aperture blades of the iris unit 45. Thus, the
influence of diffraction can be eliminated, and an

1 image including a good out-of-focus image by the iris
can be obtained.

(Eighth Embodiment)

A video camera according to the eighth embodiment
5 of the present invention will be described below with
reference to Fig. 17. The same reference numerals in
Fig. 17 denote the same parts as in Fig. 15, and a
detailed description thereof will be omitted unless
otherwise specified.

10 Referring to Fig. 17, a material element 9 such as
an electrochromic (EC) element, which can adjust the
transmission light amount by adjusting the density, is
adhered to the stationary lens 1c.

The material element 9 used in this embodiment is
15 also prepared by forming a transient metal oxide film
(IrO_2 , Ta_2O_5 , WO_3 , or the like) on the surface of a glass
plate, and can control the light transmission amount of
the film by applying a voltage to the film.

An image pickup element 10 such as a CCD has an
20 image pickup portion 10a, a color filter 10b, and a
protection glass 10c. An optical lowpass filter 47 is
arranged in front of the image pickup element 10.

Note that the arrangements and operations of
various control circuits of the video camera of this
25 embodiment are the same as those in the above
embodiment, and an illustration of the circuit

1 arrangement and a description of the operations will be
omitted.

The material element 9 may be formed on any of
lenses of the photographing optical system. For
5 example, when the photographing optical system includes
a reflection mirror, the material element may be formed
on the reflection surface of the reflection mirror.
(Ninth to 11th Embodiments)

Fig. 18 shows the ninth embodiment wherein the
10 material element 9 is formed on the rear surface of the
optical lowpass filter 47.

Fig. 19 shows the 10th embodiment wherein the
material element 9 is formed on the color filter 10b of
the image pickup element 10.

15 Fig. 20 shows the 11th embodiment wherein the
material element 9 is formed on the protection glass
10c of the image pickup element 10.

According to these embodiments, since the material
element capable of controlling the light transmission
20 factor is arranged at or near a position corresponding
to the minimum effective light beam diameter of the
photographing optical system, the material element can
be rendered compact, and its cost can be reduced.

Since the material element capable of controlling
25 the light transmission factor is arranged on the lens
surface of the photographing optical system, the
optical low pass filter, an optical member of the image

1 pickup element, or the like, the material element can
be rendered compact, its cost can be reduced, and the
material element can be easily held. In addition,
electrical wiring to the material element can be
5 simplified.

When the material element is arranged at a
position adjacent to the stationary optical system or
the filter, the material element can be easily held by
the holding member for the stationary optical system or
10 the filter.

When both the iris for mechanically adjusting the
aperture area using aperture blades and the material
element are used, an optical system lens barrel which
can eliminate deterioration of image quality caused by
diffraction, and ^{which} can provide a good out-of-focus image
15 by the iris, can be provided.
(12th Embodiment)

The 12th embodiment of the present invention will
be described below.

20 In recent years, cameras, each of which extracts
some light beams from a photographing optical system,
guides the extracted light beams onto a photoelectric
conversion element such as a CCD, and performs an
auto-focus (AF) operation, an auto-exposure (AE)
25 operation, and the like, have become popular.

In view of ease in use, such a camera is required
to be rendered compact, and compact cameras have been

1 developed by means of high-density electrical circuit
packages, compact photographing optical systems, and
the like. As a means for making the photographing
optical system compact, a camera, which adjusts the
5 amount of light incident on the image pickup plane
using a material element, has been proposed.

Similarly, in a video camera, which converts an
object image picked up by a photographing optical
system into an electrical signal using a photoelectric
10 conversion element such as a CCD, and records the
electrical signal on a recording medium such as a
magnetic tape, it has been proposed to adjust the
amount of light incident on the image pickup plane
using a material element so as to realize a compact
15 camera.

However, when the amount of light incident on the
image pickup plane is to be adjusted by the material
element constituted by a polarization plate and a
liquid crystal, light passing through the material
20 element is undesirably converted into linearly
polarized light. When this light is incident on the
reflection surface of a quick-return mirror, a
pentagonal prism, or the like, the reflectance of the
light varies depending on the direction of
25 polarization. For this reason, the amount of light
incident on the image pickup element for the AE or AF
operation becomes different from the amount of light

1 incident on the image pickup plane, thus disturbing a
precise AE or AF operation.

Assume that the amount of light incident on the
image pickup plane of a video camera including an image
5 pick element such as a CCD is to be adjusted using the
material element. In this case, since the light
transmitted through the material element is undesirably
converted into linearly polarized light, even if this
light is incident on an optical lowpass filter
10 consisting of, e.g., crystal, an optical lowpass effect
cannot be obtained.

Thus, this embodiment provides a camera and a
video camera, which can solve the above-mentioned
problems, and can make a photographing optical system
15 lens barrel compact by adjusting the amount of light
incident on the image pickup plane using a material
element having a polarization plate.

As a practical means, there is provided a camera,
which has a photographing optical system, a material
20 element, having polarization means, for controlling a
light transmission factor or amount in the
photographing optical system, light reflection means,
and photoelectric conversion means arranged on the
image pickup plane of the photographing optical system
25 or on a plane optically equivalent to the image pickup
plane, comprising circularly polarizing light
conversion means arranged on the image pickup plane

1 side of the material element or the side of the plane
optically equivalent to the image pickup plane, wherein
the light reflection means is arranged between the
photoelectric conversion means and the circularly
5 polarizing light conversion means. The material
element and the circularly polarizing light conversion
means are integrally arranged. There is also provided
a camera, which has a photographing optical system, a
material element, having polarization means, for
10 controlling a light transmission factor or amount in
the photographing optical system, light reflection
means, and photoelectric conversion means arranged on
the image pickup plane of the photographing optical
system or on a plane optically equivalent to the image
15 pickup plane, wherein the material element is arranged
between the image pickup plane and the light reflection
means.

According to this embodiment, there is provided a
video camera, which has a photographing optical system
20 including a material element, having polarization
means, for controlling a light transmission factor or
amount, and an optical lowpass filter, and has
photoelectric conversion means arranged on the image
pickup plane of the photographing optical system or on
25 a plane optically equivalent to the image pickup plane,
comprising circularly polarizing light conversion means
arranged on the image pickup plane side of the material

1 element or the side of the plane optically equivalent
to the image pickup plane, wherein the optical lowpass
filter is arranged between the photoelectric conversion
5 means and the circularly polarizing light conversion
means. There is also provided a video camera, which
has a photographing optical system including a material
element, having polarization means, for controlling a
light transmission factor or amount, and an optical
10 lowpass filter, and has photoelectric conversion means
arranged on the image pickup plane of the photographing
optical system or on a plane optically equivalent to
the image pickup plane, wherein the material element is
arranged between the photoelectric conversion means and
the optical lowpass filter.

15 With this arrangement, a photographing optical
system lens barrel can be rendered compact, thus
providing a compact camera and a compact video camera.

The 12th embodiment of the present invention will
be described below with reference to the accompanying
20 drawings. Fig. 21 is a schematic sectional view
showing a camera according to the 12th embodiment of
the present invention, Fig. 22 is a block diagram
showing a circuit arrangement of this embodiment, and
Fig. 23 is a flow chart showing an operation of this
25 embodiment.

Referring to Figs. 21 to 23, a camera has a lens
unit A and a camera body unit B. The lens unit A

1 includes a photographing optical system 101 constituted
by a focus lens 101a, zoom lenses 101b and 101c, and a
stationary lens 101d. A focus lens holding frame 102
holds the focus lens 101a, and has a gear portion 102a.
5 A stationary portion 103 is threadably engaged with the
focus lens holding frame 102. The focus lens holding
frame 102 is pivoted by a focus motor 104. A gear 104a
is attached to the output shaft of the motor 104, and
is engaged with the gear portion 102a of the focus lens
10 holding frame 102. A material element 105 consisting
of a polarization plate and a liquid crystal is
arranged in front of the stationary lens 101d. A
quarter-wave plate 107 is attached to the material
element 105, and constitutes circularly polarizing
15 light conversion means. The lens unit also includes a
lens mount 108, and an optical axis 109 of the
photographing optical system. The camera body unit B
includes a quick-return mirror 111 having a half mirror
portion, a sub mirror 112 attached to the quick-return
20 mirror 111, a shutter unit 113, a pentagonal prism 114,
a finder lens 115, an image pickup plane 116 such as a
film surface, a camera contact 117, a camera mount 118
which can be coupled to the lens mount 108, an AF
sensor unit 119 having a photoelectric conversion
25 element 119a such as a CCD, an AE sensor unit 120
having a photoelectric conversion element, and a motor
121 for driving the quick-return mirror 111. The lens

1 unit A also includes a lens control circuit 122
electrically connected to the focus motor 104, the
material element 105, and a lens contact 106. The
camera unit B further includes a camera control circuit
5 123, and a power source 124 electrically connected to
the camera control circuit 123. The camera control
circuit 123 is electrically connected to the shutter
unit 113, the camera contact 117, the AF sensor unit
119, the AE sensor unit 120, and the motor 121. The
10 lens control circuit 122 and the camera control circuit
123 are electrically connected to each other via the
lens contact 106 and the camera contact 117.

The operation of the embodiment shown in Fig. 21
will be described below with reference to Figs. 22 and
15 23. When a power switch (not shown) of the camera is
operated, and the power source 124 is turned on (S51),
the light transmission factor of the material element
105 is set to be maximum (S52). When a photographer
determines a composition, and depresses a release
20 button (not shown) to its half-stroke position, a
switch 1 (Fig. 22) is turned on (S53). When the camera
control circuit 123 detects that the switch 1 is turned
on, the AE sensor unit 120 having the photoelectric
conversion unit measures the luminance of an object.
25 Also, the AF sensor unit 119 having the photoelectric
conversion element measures the movement amount of the
focus lens 101a for a focusing operation via a

1 photometry circuit 128 and a distance measuring circuit
129 on the basis of light transmitted through the half
mirror portion of the quick-return mirror 111, and
reflected by the sub mirror 112. In addition, a power
5 source voltage is checked (S54). Then, the shutter
speed, the light transmission factor of the material
element 105, and the movement amount of the focus lens
101a are decided (S55). In this camera, the focus lens
holding frame 102 is threadably engaged with the
10 stationary portion 103, and the rotation of the focus
motor 104 is transmitted to the focus lens holding
frame 102 via the gear 104a and the gear portion 102a.
For this reason, when the focus motor 104 is rotated by
a focus motor control circuit 125, the focus lens 101a
15 is moved in the optical axis direction while being
rotated. The focus motor 104 is rotated based on the
decided movement amount of the focus lens 101a to move
the focus lens 101a to an in-focus position, thus
achieving an AF operation (S56). When the release
20 button is further depressed from this state, a switch 2
(Fig. 22) is turned on (S57). When the camera control
circuit 123 detects that the switch 2 is turned on, a
material element control circuit 126 changes the light
transmission factor of the material element 5 to the
25 decided value (S59), and a quick-return mirror control
circuit 131 causes the quick-return mirror 111 to
~~be displaced~~ *escape* from a light beam ~~path~~ (S60), as shown by the broken

1 line in Fig. 21. A shutter control circuit 130
opens/closes the shutter unit 113 in accordance with
the decided shutter speed value, thus performing
exposure on the image pickup plane (film surface) 116
5 (S61). The quick-return mirror 111 is returned to an
original position (S62), and the light transmission
factor of the material element 105 is set to be maximum
again (original state) (S63). Then, a film is fed by
one frame, thus ending a photographing operation (S64).

10 The function of the quarter-wave plate 107
constituting the circularly polarizing light conversion
means will be described below. When light incident
from the object side (the left side in Fig. 21) into
the photographing optical system is transmitted through
15 the material element 105 having the polarization plate,
it is converted into linearly polarized light. When
the linearly polarized light is incident on the
reflection surfaces of the quick-return mirror 111,
since the reflectance varies depending on the direction
20 of linear polarization, the sub mirror 112, and the
pentagonal prism 114, the amount of light incident on
the AE sensor unit 120 and the AF sensor unit 119
varies depending on the direction of linear
polarization even when the incident light amount
25 remains the same, and precise photometry and distance
measuring operations cannot be performed. In other
words, precise AE and AF operations cannot be

1 performed. In order to perform precise photometry and
distance measuring operations, the linearly polarized
light must be converted into non-polarized light or
circularly polarized light. Since the quarter wave
5 plate 107 has a function of converting linearly
polarized light into circularly polarized light, the
quarter wave plate 107 can be arranged at an
intermediate position between the material element 105
and the reflection surfaces of the optical elements, so
10 that light incident on each reflection surface can be
converted into circularly polarized light.

Like
15 ~~Like~~ in this embodiment, when the quarter wave
plate 107 and the material element 105 are integrally
arranged, they can be arranged as a unit, and can be
easily held. Note that the quarter wave plate 107 and
the material element 105 need not always be integrally
arranged.

(13th Embodiment)

20 The 13th embodiment of the present invention will
be described below with reference to the accompanying
drawings. Fig. 24 is a schematic sectional view
showing an arrangement of a camera according to the
13th embodiment of the present invention, and Fig. 25
is a block diagram showing a circuit arrangement of the
25 13th embodiment.

Note that the same reference numerals in Figs. 24
and 25 denote the same parts or functions as in

1 Figs. 21 and 22, and a detailed description thereof
will be omitted. Since the operation of the camera of
the 13th embodiment is the same as that in the 12th
embodiment of the present invention, a flow chart for
5 controlling the operation of this embodiment will be
omitted.

In the arrangement of the 13th embodiment, the
material element 105 constituted by the polarization
plate and liquid crystal is arranged between the
10 quick-return mirror 111 and the image pickup plane
(film surface) 116, and hence, the quarter wave plate
is omitted. Except for this arrangement, the
arrangement of the 13th embodiment is substantially the
same as that of the 12th embodiment of the present
invention. In this embodiment, ^{before} when the quick-return
15 mirror 111 ~~escapes~~ ^{is displaced} from a light beam ^{path} (i.e., to a
position indicated by a broken line in Fig. 24), i.e.,
in an operation other than a photographing operation,
light incident from the object side (the left side in
20 Fig. 24) into the photographing optical system is
transmitted through the reflection surfaces of the
quick-return mirror 111, the sub mirror 112, and the
pentagonal prism 114, is then incident on the AE sensor
unit 120 and the AF sensor unit 119, and is used for
25 photometry and distance measuring operations. When the
quick-return mirror 111 ^{is displaced} ~~escapes~~ from a light beam in
the photographing operation, light transmitted through

1 the photographing optical system is incident on the
material element 105, and is subjected to light amount
adjustment in a material element control circuit 133 to
be converted into linearly polarized light. The
5 linearly polarized light reaches the image pickup plane
(film surface) 116. With this arrangement, precise
photometry and distance measuring operations can be
performed.

In addition, the camera of the 12th or 13th
10 embodiment is an exchangeable lens type camera, but may
be a lens integrated type camera.
(14th Embodiment)

Fig. 26 is a schematic sectional view showing a
video camera according to the 14th embodiment of the
15 present invention.

The same reference numerals in Fig. 26 denote the
same parts or functions as in Figs. 21 and 24, and a
detailed description thereof will be omitted. A cam
cylinder 134 for determining the positions of the zoom
20 lenses 101b and 101c is rotatably held by a stationary
portion 103. The zoom lenses 101b and 101c are held by
lens frames 135 and 136. The focus lens holding frame
102 is pivoted by a focus motor 137. A gear 137a is
attached to the output shaft of the motor 137, and is
25 engaged with the gear portion 102a of the focus lens
holding frame 102. The cam cylinder 134 is pivoted by
a zoom motor 138. A gear 138a is attached to the

1 output shaft of the motor 138, and is engaged with a
gear portion 134a of the cam cylinder 134. A material
element 139 is constituted by a polarization plate and
a liquid crystal. An image pickup element 140
5 comprises, e.g., a CCD. The photographing optical
system has an optical axis 141. The camera of this
embodiment also includes an electronic viewfinder 142
having a lens 143, a power switch 144, a zoom operation
unit 145, a quarter wave plate 146 adhered to the
10 material element 139, and constituting circularly
polarizing light conversion means, and an optical
lowpass filter 147 utilizing birefringence. The camera
further includes a camera control circuit, a recording
unit, and a power source, which are electrically
15 connected to the camera control circuit. The camera
control circuit is also electrically connected to the
focus motor 137, the zoom motor 138, the material
element 139, the image pickup element 140, the
electronic viewfinder 142, the power switch 144, and
20 the zoom operation unit 145.

Note that the circuit arrangement and the control
operation of the above-mentioned camera are the same as
those in the circuit block diagram of Fig. 2, and the
flow chart of Fig. 4 in the first embodiment, and a
25 detailed description thereof will be omitted.

The function of the quarter-wave plate 146
constituting the circularly polarizing light conversion

1 means will be described below. In a photographing
operation, when light incident from the object side
(the left side in Fig. 26) into the photographing
optical system is transmitted through the material
5 element 139 having the polarization plate, it is
converted into linearly polarized light. Even when the
linearly polarized light is incident on the optical
lowpass filter 147 utilizing birefringence, an optical
lowpass effect cannot be obtained. In order to obtain
10 the function of the optical lowpass filter 147, the
linearly polarized light must be converted into
non-polarized light or circularly polarized light.
Since the quarter wave plate 146 has a function of
converting linearly polarized light into circularly
15 polarized light, the quarter wave plate 146 can be
arranged at an intermediate position between the
material element 139 and the optical lowpass filter
147, so that light incident on the optical lowpass
filter 147 can be converted into circularly polarized
20 light. *Like* in this embodiment, when the quarter wave
plate 146 and the material element 139 are integrally
arranged, they can be arranged as a unit, and can be
easily held. Note that the quarter wave plate 146 and
the material element 139 need not always be integrally
25 arranged.

1 (15th Embodiment)

Fig. 27 is a schematic sectional view showing a video camera according to the 15th embodiment of the present invention. The same reference numerals in
5 Fig. 27 denote the same parts as in the 14th embodiment shown in Fig. 26, and a detailed description thereof will be omitted. Also, since the circuit arrangement and operation of this embodiment are the same as those in the 14th embodiment (as in Figs. 2 and 4), blocks
10 representing the circuit arrangement and the flow chart for controlling the operation will be omitted in this embodiment as well.

In the arrangement of this embodiment, the material element 139 constituted by a polarization
15 plate and a liquid crystal is arranged between the optical lowpass filter 147 utilizing birefringence, and the image pickup element 140 such as a CCD, and no quarter wave plate is used. Except for this arrangement, the arrangement of this embodiment is
20 substantially the same as that of the 14th embodiment of the present invention. In this embodiment, in a photographing operation, light incident from the object side (the left side in Fig. 27) into the photographing optical system is transmitted through the optical
25 lowpass filter 147, and is subjected to an optical lowpass effect. Thereafter, the light is incident on the material element 139, and is subjected to light

1 amount adjustment. Thus, the light is converted into
linearly polarized light, and reaches the image pickup
element 140. With this arrangement, an optical lowpass
effect can be obtained.

5 In addition, the video camera of the 14th or 15th
embodiment of the present invention is a lens
integrated type camera, but may be applied to an
exchangeable lens type video camera.

As described above, according to the 12th
10 embodiment, in a camera including a material element
capable of controlling a light transmission factor or
amount using polarization means in a photographing
optical system, circularly polarizing light conversion
means is arranged at the prospective imaging plane side
15 of the material element, light reflection means is
arranged between the circularly polarizing light
conversion means and the prospective imaging plane, and
the material element is arranged between the
prospective imaging plate and the light reflection
20 means. Therefore, a compact camera, which can perform
precise AE and AF operations without arranging any
exclusive circularly polarizing light conversion means
can be provided.

Also, in a video camera including a material
25 element capable of controlling a light transmission
factor or amount using polarization means in a
photographing optical system, circularly polarizing

1 light conversion means is arranged at the image pickup
element side of the material element, an optical
lowpass filter is arranged between the circularly
polarizing light conversion means and the image pickup
5 element, and the material element is arranged between
the image pickup element and the optical lowpass
filter. Therefore, a compact video camera, which can
reliably obtain an optical lowpass effect, can be
provided.

10 (16th Embodiment)

The 16th embodiment of the present invention will
be described below..

When the amount of light incident on a
photoelectric conversion element such as a CCD is
15 adjusted by a material element such as an EC
(electrochromic) element or a liquid crystal element,
if control of the material element is stopped by
turning off the power source of the camera or setting
the camera in a reproduction mode when the light
20 transmission factor of the material element is high,
light having a strong light intensity, such as sunlight
is incident on the photoelectric conversion element,
and a damage may be caused in the photoelectric
conversion element.

25 Since the photoelectric conversion element has
high sensitivity to near infrared light outside a
visible light range, a camera having the photoelectric

1 conversion element such as a CCD on the imaging plane
of the photographing optical system or on a plane
optically equivalent to the imaging plane has a near
infrared light cut filter in the photographing optical
5 system. Easy assembling of the near infrared light cut
filter is a subject for realizing a compact, low-cost
camera.

It is an object of this embodiment to provide a
compact, low-cost camera having a photoelectric
10 conversion element on an imaging plane of a
photographing optical system or on a plane optically
equivalent to the imaging plane, which camera adjusts
the amount of light incident on the imaging plane by a
material element, can prevent an image pickup element
15 from being damaged with light having a high light
intensity when the image pickup element is inactive,
can improve easiness of assembling of the near infrared
light cut filter, and can realize a compact, low-cost
photographing optical system lens system.

20 For this reason, according to this embodiment,
there is provided a camera, which has a material
element capable of controlling a light transmission
factor or amount in a photographing optical system, and
has photoelectric conversion means on an imaging plane
25 of the photographing optical system or on a plane
optically equivalent to the imaging plane, wherein the
material element has a filter function of removing near

1 infrared light. The material element and a filter for
removing near infrared light are integrally arranged.
The camera also has correction means for correcting the
light transmission factor wavelength dependency
5 characteristics of the material element. The camera
further has storage means for storing the light
transmission factor wavelength dependency
characteristics of the material element obtained when
the material element is in a predetermined state. The
10 storage means stores a plurality of material element
light transmission factor wavelength dependency
characteristics when the light transmission factor of
the material element is a predetermined value. The
camera further has temperature detection means, and the
15 storage means stores a plurality of material element
light transmission factor wavelength dependency
characteristics under a predetermined temperature
condition. When the photoelectric conversion means
does not perform a photoelectric conversion operation,
20 the material element is set in a light shielding state
or a substantially minimum light transmission factor
state or a substantially minimum light transmission
amount state, or when the photoelectric conversion
means does not perform a photoelectric conversion
25 operation, voltage application to the material element
is stopped. At this time, when the voltage application
to the material element is stopped, the light

1 transmission factor or amount is held in a state
wherein voltage application to the material element is
stopped. Furthermore, when the photoelectric
conversion means stops a photoelectric conversion
5 operation, the material element is set in a light
shielding state or a substantially minimum light
transmission factor state or substantially minimum
light transmission amount state, and thereafter,
voltage application to the material element is stopped.
10 When the power switch of the video camera is turned
off, the material element is set in a light shielding
state or a substantially minimum light transmission
factor state or substantially minimum light
transmission amount state. The camera further includes
15 reproduction means for reproducing a recorded image.
When the video camera is set in a reproduction state of
a recorded image or in a reproduction mode of a
recorded image, the material element is set in a light
shielding state or a substantially minimum light
20 transmission factor state or substantially minimum
light transmission amount state. The material element
is one which can be set in a light shielding state or a
substantially minimum light transmission factor state
or substantially minimum light transmission amount
25 state.

With the arrangement of this embodiment, a
photographing optical system lens barrel can be

1 rendered compact, and its cost can be reduced, thus
providing a compact, low-cost camera.

The 16th embodiment of the present invention will
be described below with reference to the accompanying
5 drawings. Since the arrangement and operation of the
video camera of this embodiment are the same as those
shown in Figs. 1 to 4 described in the first
embodiment, a detailed description and illustration
thereof will be omitted.

10 In this embodiment, a difference from the first
embodiment is that a near infrared light cut filter
function is added to the material element 9.

The material element 9 having the near infrared
light cut filter function will be described below.

15 Fig. 28 shows an example of the spectral
transmission characteristics of the near infrared light
cut filter. Normally, an image pickup element such as
a CCD has relatively high sensitivity to near infrared
light. For this reason, in a camera having such an
20 image pickup element, a near infrared light cut filter
having spectral transmission factor characteristics
shown in Fig. 28 is arranged at the light-receiving
portion side of the image pickup element. For this
reason, when a material element having spectral
25 transmission characteristics shown in Fig. 29 (a solid
curve in Fig. 29 represents a maximum transmission
state of the material element, and characteristics

1 obtained when the light transmission factor is lowered
are represented in the order of a broken curve, an
alternate long and short dashed curve, and an alternate
long and two short dashed curve) is used as light
5 amount adjustment means for the photographing optical
system, since this material element has a function of a
near infrared light cut filter, the near infrared light
cut filter need not be arranged in addition to the
material element. A material element having spectral
10 transmission characteristics shown in Fig. 30 (a solid
curve in Fig. 30 represents a maximum transmission
state of the material element, and characteristics
obtained when the light transmission factor is lowered
are represented in the order of a broken curve, an
15 alternate long and short dashed curve, and an alternate
long and two short dashed curve), and a near infrared
light cut filter having characteristics shown in
Fig. 28 are integrally arranged to constitute a light
amount adjustment unit having spectral transmission
20 characteristics shown in Fig. 29. Examples of the
light amount adjustment unit will be explained below
with reference to Figs. 31 to 35. In Figs. 31 to 35,
common reference numerals are used. The light amount
adjustment unit includes a near infrared light cut
25 filter 216, a material element 217, and an EC
(electrochromic) element 218 consisting of a transition
metal oxide film (e.g., IrO_x , Ta_2O_5 , WO_3 , or the like).

1 When a voltage is applied to this film, the
transmission light amount of the film can be
controlled. The adjustment unit also includes a liquid
crystal 219, a polarization plate (or a glass plate)
5 220, an electrical signal line 221, and a glass plate
222. The above-mentioned light amount adjustment unit
is prepared by integrally arranging the material
element 217 and the near infrared light cut filter 216,
as shown in Fig. 31. When the material element 217
10 comprises an EC element, the EC element 218 may be
formed on the surface of the near infrared light cut
filter 216 by deposition, as shown in Fig. 32, or the
glass plate 222 on which the EC element 218 is
deposited may be adhered to the near infrared light cut
15 filter 216, as shown in Fig. 33. One of the material
element 217 and the polarization plate (or glass plate)
220 sealed with a liquid crystal may be used as the
near infrared light cut filter 216, or the liquid
crystal element and the near infrared light cut filter
20 216 may be adhered to each other, as shown in Fig. 35.
The electrical signal line 221 shown in each of
Figs. 31 to 35 is connected to the camera control
circuit 21, and the material element 217 is controlled
by the exposure amount control circuit 26.
25 (17th Embodiment)

The 17th embodiment of the present invention will
be described below. The schematic arrangement of a

1 camera of this embodiment is basically the same as that
shown in Fig. 21. The circuit arrangement of this
embodiment is the same as that shown in the block
diagram of Fig. 22, and operation control of the entire
5 camera is the same as that shown in the flow chart of
Fig. 23.

Therefore, the explanation for the arrangement and
the operation shown in Figs. 21, 22, and 23 is used for
those of this embodiment.

10 In this embodiment, however, the quarter wave
plate 107 in Fig. 21 may be omitted.

An image pickup element such as a CCD used in,
e.g., an AF sensor unit has relatively high sensitivity
to near infrared light. For this reason, a near
15 infrared light cut filter having spectral transmission
factor characteristics shown in Fig. 28 is arranged at
the light-receiving portion side of the image pickup
element. For this reason, when the material element of
the 16th embodiment of the present invention is used as
20 a material element as light amount adjustment means in
a photographing optical system of this embodiment,
since the material element has a near infrared light
cut filter function, another near infrared light cut
filter need not be arranged. If light amount
25 adjustment units having the arrangements (i.e.,
integrated arrangements of the material element and the
near infrared light cut filter) and spectral

1 transmission characteristics shown in Figs. 31 to 35
like those in the 16th embodiment are used as the
material element of this embodiment, the same effect
can be obtained. In this case, in this embodiment, the
5 electrical signal line 221 shown in each of Figs. 31 to
35 is connected to the lens control circuit 122
(Fig. 22), and the material element 105 is controlled
by the material element control circuit 126.

10 In addition, the 16th embodiment of the present
invention is applied to a photographing optical system
integrated video camera, and the 17th embodiment of the
present invention is applied to an exchangeable lens
type camera. However, these embodiment may be applied
to either a photographing optical system integrated
15 camera or an exchangeable lens type camera.
(18th Embodiment)

The 18th embodiment of the present invention will
be described below. This embodiment compensates for a
change in light transmission factor wavelength
20 dependency of a material element caused by a change in
temperature.

The schematic arrangement of a video camera
according to the 18th embodiment of the present
invention is the same as that shown in Fig. 21, and
operation control of this camera is the same as that
25 shown in the flow chart of Fig. 23. Fig. 36 is a block
diagram showing a circuit arrangement of this

1 embodiment, Fig. 37 is a graph showing the light
transmission factor wavelength dependency
characteristics of a material element, and Fig. 38 is a
graph showing a change in light transmission factor
5 wavelength dependency characteristics of the material
element caused by a change in temperature.

The arrangement shown in Fig. 36 is substantially
the same as that in the first embodiment shown in
Fig. 2, except that a material element spectral
10 transmission factor characteristics storage circuit 322
and a temperature detection circuit 321 are arranged.
Thus, a detailed description thereof will be omitted.

The material element 9 and the spectral
transmission factor characteristics storage circuit for
15 the material element 9 will be described below with
reference to Fig. 36.

The material element 9 comprises a liquid crystal
element or an electrochromic element, and can
electrically control the transmission amount of light.
20 It is ideal that the material element 9 has a constant
light transmission factor ^{*independent*} ~~independently~~ of the light
a wavelength. However, in general, even in a state
wherein the material element has the maximum light
transmission factor, the light transmission factor
25 changes depending on the light wavelength, as shown in
Fig. 37. In some material elements, the spectral
transmission factor changes depending on the light

1 transmission factor, as indicated by, e.g., a broken
curve in Fig. 37. In some cases, the spectral
transmission factor may change depending on the
temperature condition, as shown in Fig. 38. In order
5 to prevent a color balance error of a camera due to use
of this material element, this embodiment comprises the
material element spectral transmission factor
characteristics storage circuit 322 for storing the
spectral transmission factor characteristics of the
10 material element under respective conditions. The
light transmission state of the material element, the
temperature condition, and the like are detected by the
camera control circuit or the temperature detection
circuit 321, and white balance is corrected by the
15 camera control circuit 123 on the basis of the spectral
transmission factor characteristics of the material
element 9 stored in the material element spectral
transmission factor characteristics storage circuit
322.

20 The operation of the 18th embodiment is the same
as that shown in the flow chart of Fig. 4. That is,
when the light transmission amount of the material
element is controlled by the exposure amount control
circuit, so that the amount of light incident on the
25 image pickup element becomes constant, white balance is
simultaneously corrected so as to prevent the

1 above-mentioned color balance error caused by material
 element 9 (see Fig. 6).

In addition, when the spectral transmission factor characteristics of the material element do not ^{greatly}~~largely~~ change due to a change in temperature, the temperature detection circuit 321 of this embodiment may be omitted, and white-balance correction due to the change in temperature may be omitted.

In this embodiment, the material element spectral transmission factor characteristics storage circuit 322 is controlled by the camera control circuit 123. In the case of an exchangeable lens type camera, the material element spectral transmission factor characteristics storage circuit 322 may be arranged on the exchangeable lens side.

When color balance does not ~~largely~~ change depending on the transmission factor of the material element, typical spectral transmission factor characteristics of the material element may be stored.

20 Color-balance correction is not limited to
white-balance correction. For example, the color
balance may be corrected by any other methods (e.g., by
changing the transmission factor of the color filter of
the image pickup element).

25 (19th Embodiment)

1 present invention, Fig. 40 is a block diagram showing a
circuit arrangement of this embodiment, and Figs. 41A
to 41C are flow charts for controlling the operation
of the video camera of this embodiment.

5 The same reference numerals in Fig. 39 denote the
same parts or functions as in Fig. 1 of the first
embodiment, and a detailed description thereof will be
omitted.

10 Referring to Fig. 39, a mode change switch 400 is
used for switching an operation mode between a
recording mode and a reproduction mode. The camera has
the camera control circuit 21, and the recording unit
22 and the power source 23, which are electrically
connected to the camera control circuit 21. The camera
15 control circuit 21 is also electrically connected to
the focus motor 7, the zoom motor 8, the material
element 9, the image pickup element 10, the electronic
viewfinder 12, the power switch 14, the zoom operation
unit 15, and the mode change switch 400.

20 The operation of this embodiment will be described
below with reference to Figs. 40 and 41A to 41C. In the
following description, a brief explanation will be
given for the same points as in the first embodiment
shown in Figs. 1 and 2.

25 The power switch 14 of the camera is operated to
turn on the power source (S101), and it is checked if
the camera is set in a recording mode by the mode

1 change switch 400 (S102). If YES in step S102, the
image pickup element is driven to move the focus lens
1a in the optical axis direction, so that the
high-frequency components of a video signal output from
5 the image pickup element 10 become ^{maximized} maximum. The light
transmission amount of the material element is
controlled to obtain a constant image pickup signal
level, thus performing exposure amount control (S104).
At this time, the electronic viewfinder is turned on,
10 and a photographed image can be observed (standby
state).

It is checked if the power switch is ON (S106), it
is checked if the recording mode is selected (S107),
and it is then checked if the photographing switch is
15 ON (S108). If it is determined in step S108 that the
photographing switch is ON, image recording is started
(step S109), and the forward/backward rotation of the
zoom motor is controlled in accordance with the ON/OFF
states of the zoom switches 1 and 2, thus allowing a
20 zoom operation during a photographing operation (S110
to S114). It is checked again if the photographing
switch is ON (S115). If YES in step S115, the flow
returns to step S110; otherwise, image recording is
stopped (S116), the zoom motor is stopped (S117), and
25 the control returns to the standby state in step S106.

Even if it is determined in step S108 that the
photographing switch is OFF, processing in steps S118

1 to S120 allows a zoom operation. A zoom operation in
this case is the same as that in steps S110 to S114.

If it is determined in step S107 that the mode
change switch is turned off to select a reproduction
5 mode, the focus lens is stopped to stop a focusing
operation (S123), and the drive operation of the
material element is stopped to stop an exposure control
operation (S124). Also, the drive operation of the
image pickup element is stopped (S125). Furthermore,
10 the light transmission factor of the material element
is held to be a minimum value (S126). Thus, scorching
of, e.g., the image pickup element due to incidence of
strong light can be prevented. In this manner, the
operation mode can be switched from the recording
15 standby state to the reproduction mode.

If it is determined in step S106 that the power
switch is turned off, the focusing operation is stopped
(S127), the exposure amount control operation is
stopped (S128), and the drive operation of the image
20 pickup element is stopped (S129). Thereafter, the
light transmission factor of the material element is
held to be a minimum value (S130), and the electronic
viewfinder is turned off (S131). Thus, the control
ends (S132).

25 When the power switch 14 of the camera is operated
to turn on the power source, and the camera is set in
the reproduction mode by the mode change switch 400

1 (S102), the light transmission factor of the material
element 9 is held to be a minimum value by the exposure
amount control circuit 105. At this time, when a
reproduction button (not shown) is depressed (S133), an
5 image stored in a recording medium inserted in the
camera is displayed on the electronic viewfinder 12
(S134). When a stop button (not shown) is depressed
(S135), the image reproduction is stopped (S136). In
this state, when the power switch 14 is turned off, the
10 camera control circuit 21 confirms that the power
switch 14 is turned off, and the image display on the
electronic viewfinder is stopped. At the same time,
the material element 9 is held in a minimum light
transmission factor state. In this manner, the power
15 source of the camera is turned off (S137 - S130).

When the camera control circuit 21 confirms that
the operation mode of the camera is switched from the
reproduction mode to the recording mode by the mode
change switch 400 (S138), the drive operation of the
20 image pickup element 10, the focusing operation, the
zoom operation, the exposure amount control operation,
and the like are started, as described above, and the
camera is set in the standby state of the recording
mode (S138 - S103).

25 A method of setting the light transmission factor
or amount of the material element in a minimum state,

1 and holding this state in this embodiment will be
described below.

When the light transmission factor or amount of
the material element of this embodiment becomes minimum
5 if no voltage is applied to the material element (e.g.,
a negative type liquid crystal element), energization
to the material element need only be turned off so as
to set the light transmission factor or amount of the
material element in a minimum state and to hold this
10 state.

When the light transmission factor or amount of
the material element of this embodiment is held in a
state obtained when energization to the material
element is turned off (e.g., an EC element),
15 energization need only be performed until the light
transmission factor or amount of the material element
has a minimum state, and thereafter, the energization
can be turned off, so as to set the light transmission
factor or amount of the material element in a minimum
20 state and to hold this state (for example, a constant
voltage is applied for a predetermined period of time).

When the image pickup element is not active (e.g.,
when the power source of the camera is OFF, when the
camera is set in the reproduction mode, and the like),
25 the material element 9 is held in the minimum light
transmission state, but may be held in a state near the

1 minimum light transmission state or in a light
shielding state.

As described above, according to the 16th to 19th
embodiments of the present invention, in the camera
5 which has the photographing optical system including
the material element capable of controlling the light
transmission factor or amount, and the photoelectric
conversion means on the imaging plane of the
photographing optical system or on a plane optically
10 equivalent to the imaging plane, since the material
element has a near infrared light cut filter function
or is arranged integrally with a near infrared light
cut filter, ^{ease}~~easiness~~ of assembling of the near infrared
light cut filter can be improved, and the size and cost
15 of the photographing optical system lens barrel can be
reduced, thus providing a compact, low-cost camera.

Since the material element light transmission
factor wavelength dependency characteristics storage
circuit and the color balance correction means are
20 arranged, the material element can be used in place of
a conventional iris for mechanically adjusting an
aperture portion, and a drive unit for the iris for
mechanically adjusting the aperture portion can be
omitted, thus providing a compact photographing optical
25 system lens barrel, i.e., a compact video camera.

1 Also, the material element can be used in an
exchangeable lens type video camera in place of the
conventional iris.

5 In the video camera, which has the photographing
optical system including the material element capable
of controlling the light transmission factor or amount,
when the image pickup element is not active, or when
the power source of the camera is turned off, the
material element is set in a light shielding state, or
10 a minimum light transmission factor state or a state
near the minimum light transmission factor state, or a
minimum light transmission amount state or a state near
the minimum light transmission amount state. For this
reason, a compact video camera which can eliminate ~~a~~
15 damage to the image pickup element ^{due to} ~~upon~~ incidence of
light having a strong light intensity can be provided.

The 19th embodiment of the present invention will
be described below.

20 This embodiment relates to an optical system
having a light amount adjustment device and, more
particularly, to an optical system having a light
amount adjustment system, which is suitable for a
camera such as a video camera, an electronic still
camera, a still camera, and the like, which camera can
25 widen the passing light amount adjustment range of the
optical system by arranging a plurality of material
elements capable of arbitrarily adjusting the

1 transmission factor (light transmission factor) in the
optical path of the optical system.

As described above, in order to realize a compact
photographing optical system, attempts have been made
5 to control the light amount adjustment range of the
optical system by arranging a material element such as
a liquid crystal element, an electrochromic (EC)
element, or the like in the optical path of the optical
system as a light amount adjustment device for
10 adjusting the amount of light incident on an imaging
plane in a video camera.

Even in a camera using a silver chloride film, a
proposal has been made to control the amount of light
beam incident on an imaging plane by utilizing a
15 material element such as a liquid crystal element so as
to realize an electronic iris device.

The conventional iris device for performing light
amount adjustment by mechanically moving aperture
blades to change the aperture size allows about 10 to
20 12 iris steps (the light amount ratio (maximum
transmission light amount/minimum transmission light
amount) of about 1,000 to 4,000) of light amount
adjustment in a video camera. Also, in a video camera
using a silver chloride film, the iris device allows
25 about 5 to 8 iris steps (the light amount ratio of
about 30 to 250) of light amount adjustment.

1 The light amount adjustment devices used in these
cameras can adjust the passing light amount
(transmission light amount) within a relatively wide
range. However, the entire device becomes large in
5 size, and is complicated.

 In contrast to this, in another light amount
adjustment device, a material element such as a liquid
crystal element, an EC element, or the like is solely
arranged in an optical path of an optical system, and
10 the amount of light incident on an imaging plane is
adjusted by changing the transmission factor of the
material element. Such a light amount adjustment
device is suitable for achieving the photographing
optical system. However, it is difficult for this
15 light amount adjustment device to perform light amount
adjustment within a range as wide as that of the
above-mentioned mechanical light amount adjustment
device (iris device).

 For this reason, the light amount adjustment range
20 becomes insufficient, and a desired image cannot be
easily obtained.

 When the passing light amount of the optical
system is to be adjusted by changing the transmission
factor (density) of a single material element, a
25 sufficient iris effect cannot be obtained. As a
result, the depth of field cannot be increased, and
harmful light beams cannot be effectively shielded.

1 The present invention has as its object to provide
an optical system having a compact light amount
adjustment device, which can obtain a wider light
amount adjustment range, and can obtain a sufficient
5 iris effect by arranging a plurality of material
elements capable of arbitrarily adjusting the
transmission factor in the optical path of the optical
system.

10 An optical system having a light amount adjustment
device of this embodiment is characterized in that the
passing light amount is controlled by arranging a
plurality of material elements capable of adjusting the
transmission factor in the optical path of the optical
system.

15 Also, an optical system having a light amount
adjustment device of this embodiment is characterized
in that when the passing light amount is controlled by
arranging a plurality of material elements capable of
adjusting the transmission factor in the optical path
20 of the optical system, a light transmission region of
at least one of the plurality of material elements is
divided into a plurality of regions, and the
transmission factor of at least one of the plurality of
divided regions can be adjusted independently of the
25 other regions.

Fig. 42 is a block diagram showing an arrangement
of a video camera of this embodiment. The circuit

1 arrangement and operation control of this embodiment
are the same as those shown in the block diagram of
Fig. 2 and the flow chart of Fig. 4 according to the
first embodiment, and a detailed description thereof
5 will be omitted.

The same reference numerals in Fig. 42 denote the
same parts as in Fig. 1, and a detailed description
thereof will be omitted.

Referring to Fig. 42, material elements 9 and 401
10 comprise liquid crystal elements, electrochromic (EC)
elements (e.g., prepared by forming a conductive film
of, e.g., a transition metal oxide (IrO_x , Ta_2O_5 , WO_3 , or
the like) on the surface of a glass plate having a
thickness of about 0.3 to 1 mm), and the like. The
15 material elements 9 and 401 have a function of
arbitrarily controlling their transmission factors or
amounts upon application of a voltage thereto.

In this embodiment, the material element 9 is
arranged near an iris in an optical path between a zoom
20 lens 1b2 and the stationary lens 1c, and the material
element 401 is arranged in an optical path in front of
the focus lens 1a. The two material elements 9 and 401
arbitrarily adjust the passing light amount
(transmission light amount) of a light beam of the
25 optical system (photographing optical system 1 to widen
the light amount adjustment range, thus performing
proper exposure.

1 Other arrangements are the same as those in the
block diagram shown in Fig. 1, and the respective
components are controlled by the camera control
circuit.

5 Although the operation control sequence is the
same as that in the first embodiment shown in Fig. 4,
the light transmission amount and the light
transmission factor are controlled by a combination of
both the two material elements 9 and 401 in this
10 embodiment.

 An optical effect obtained when the two material
elements 9 and 401 according to this embodiment are
used will be described below.

 For example, assume that the minimum and maximum
15 transmission factors of the material element 9 are
represented by A_{MIN} and A_{MAX} , and the material element 9
can adjust the passing light amount (transmission light
amount) within a range from the minimum transmission
factor A_{MIN} to the maximum transmission factor A_{MAX} . At
20 this time, the minimum and maximum transmission factors
 A_{MIN} and A_{MAX} satisfy the following relation:

$$0 < A_{MIN} < A_{MAX} < 1 \quad \dots(1)$$

 A ratio (light amount ratio) R1 between the maximum
transmission factor A_{MAX} to the minimum transmission
25 factor A_{MIN} is given by:

$$R1 = A_{MAX}/A_{MIN} \quad (> 1) \quad \dots(2)$$

1 Similarly, the same for the material element 9
 applies to the material element 401. For example,
 assume that the minimum and maximum transmission
 factors of the material element 401 are represented by
 5 B_{MIN} and B_{MAX} , and the material element 401 can adjust the
 passing light amount (transmission light amount) within
 a range from the minimum transmission factor B_{MIN} to the
 maximum transmission factor B_{MAX} . At this time, the
 minimum and maximum transmission factors B_{MIN} and B_{MAX}
 10 satisfy the following relation:

$$0 < B_{MIN} < B_{MAX} < 1 \quad \dots(3)$$

A ratio (light amount ratio) R_2 between the maximum
 transmission factor B_{MAX} to the minimum transmission
 factor B_{MIN} is given by:

$$15 \quad R_2 = B_{MAX}/B_{MIN} \quad (> 1) \quad \dots(4)$$

The transmission factor (the adjustment range of
 the passing light amount) of the optical system upon
 synthesis of the material elements 9 and 401 ranges
 20 from $A_{MIN} \cdot B_{MIN}$ to $A_{MAX} \cdot B_{MAX}$.

A ratio (light amount ratio) R of the maximum
 transmission factor to the minimum transmission factor
 is given by:

$$\begin{aligned} R &= (A_{MAX} \cdot B_{MAX}) / (A_{MIN} \cdot B_{MIN}) \\ &= (A_{MAX}/A_{MIN}) \cdot (B_{MAX}/B_{MIN}) \\ 25 \quad &= R_1 \cdot R_2 \quad \dots(5) \end{aligned}$$

As can be apparent from equation (5), the value of the
 light amount ratio R is larger by R_2 ($B_{MAX}/B_{MIN} > 1$)

1 times than that obtained by, e.g., the material element
9 alone.

That is, the passing light amount adjustment using
a plurality of material elements can make the light
5 amount adjustment range wider than that using the
material element 9 alone.

In this embodiment, as described above, the two
material elements 9 and 401 are arranged in the optical
path of the optical system to widen the passing light
10 amount adjustment range, thereby obtaining desired
optical performance.

Note that the two material elements 9 and 401 in
this embodiment may have either the same or different
characteristics (transmission factor), and the present
15 invention can be applied to either case.

In this embodiment, the two material elements 9
and 401 are arranged to sandwich the optical members
(the lenses 1a, 1b1, and 1b2) therebetween. However,
the present invention is not limited to these
20 arrangement positions. For example, the two material
elements 9 and 401 may be arranged adjacent to each
other. The number of material elements is not limited
to two, but three or more material elements may be
used. Then, the passing light amount can be adjusted
25 within a still wider range.

1 (20th Embodiment)

Figs. 43A and 43B are a side view and a front view of one of a plurality of material elements according to the 20th embodiment of the present invention.

5 In this embodiment, a difference from the 19th embodiment is that at least one of two material elements is arranged near an iris position of an optical system, a region of the material element at that time is divided into a plurality of concentric regions, and the transmission factor of at least one of the divided regions can be adjusted independently of the other regions. Other arrangements and optical effects are substantially the same as those in the 19th embodiment.

10
15 More specifically, in this embodiment, one material element (represented by reference numeral 402 in this case) is divided into a plurality of concentric pattern regions 402a to 402g, as shown in Fig. 43B (although the element is divided into seven regions in this embodiment, the present invention is not limited to this number of divided regions) and the transmission factors of the divided regions 402a to 402g are independently adjusted, as shown in, e.g., Figs. 44A to 44H, thus satisfactorily obtaining a stopped-down effect (e.g., to obtain a desired image by increasing/decreasing the depth of field).

20
25

1 Referring to Figs. 44A to 44H, hatched regions
have a smaller transmission factor than that of the
other regions. The material element 402 is
independently controlled in units of regions 402a to
5 402g, so that the transmission factor is sequentially
decreased (the depth of field is sequentially
increased) from Fig. 44A toward Fig. 44H. In this
manner, the depth of field is increased/decreased to
obtain an iris effect.

10 (21st Embodiment)

Fig. 45 is a side view showing a light amount
adjustment device using material elements according to
the 21st embodiment of the present invention. Fig. 45
shows a mounting portion of the material element.

15 In this embodiment, a difference from the 19th
embodiment is that a light amount adjustment device is
constituted as a unit by forming material elements 422
and 423 respectively on a light incident surface 421a
and a light exit surface 421b of a transparent
20 substrate 421 consisting of, e.g., glass, and the unit
is arranged at an arbitrary position in the optical
path of the optical system. Other arrangements and
optical effects are substantially the same as those in
the 19th embodiment.

25 More specifically, since one material element 422
of the two material elements 422 and 423 is formed on
the light incidence surface 421a of the transparent

1 substrate 421, and the other material element 423 is
formed on the light exit surface 421b, the same effect
as in the 19th embodiment can be obtained, and the
light amount adjustment apparatus can be constituted as
5 a unit, thereby realizing a simple, compact structure
of the entire device.

Note that at least one of the two material
elements 422 and 423 may be divided into a plurality of
concentric regions, as shown in Figs. 43A and 43B
10 illustrating the 20th embodiment, and the passing light
amounts of the plurality of divided regions may be
independently adjusted. Thus, the iris effect can be
obtained as in the 20th embodiment described above.
(22nd Embodiment)

15 Figs. 46A and 46B are a side view and a front view
of a light amount adjustment device according to the
22nd embodiment of the present invention.

In this embodiment, a difference from the 21st
embodiment described above is that a material element
20 426 is formed only on a region 428 outside the area
(hatched region) of a circle 427 having the optical
axis as the center on at least one surface of a
transparent substrate 424. Other arrangements and
optical effects are substantially the same as those in
25 the 21st embodiment described above.

For example, when the passing light amount of an
optical system is to be adjusted using two material

1 elements each having a not so large maximum
transmission factor, the maximum transmission factor of
the optical system may often be considerably lowered.
For example, when two material elements each having a
5 maximum transmission factor of 90% are used, the
synthesized maximum transmission factor of the optical
system is about 81%. However, when two material
elements each having a maximum transmission factor of
50% are used, the synthesized maximum transmission
10 factor of this optical system is undesirably lowered to
about 25%.

Thus, in this embodiment, as shown in Figs. 46A
and 46B, a material element 425 is formed on
substantially the entire light incident surface 424a of
15 the transparent substrate 424 consisting of, e.g.,
glass as in the 21st embodiment, and the material
element 426 is formed only on the region 428 outside
the area (hatched region) of the circle 427 having the
optical axis as the center on a light exit surface
20 424b, thereby increasing the passing light amount.

Thus, even when a plurality of material elements
having low maximum transmission factors are used, the
synthesized maximum transmission factor can be
prevented from being considerably lowered. Also, the
25 passing light amount adjustment range can be widened to
some extent. Furthermore, a certain iris effect can be
obtained by the material element 426.

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1 Note that the area of the circle 427 on the light
exit surface 424b on which no material element is
formed can be arbitrarily set in accordance with the
characteristics (transmission factor) of a material
5 element to be used.

 In this embodiment as well, the material element
425 may be divided into a plurality of concentric
regions, and the passing light amounts of the divided
regions may be independently adjusted like in the 20th
10 embodiment described above. Alternatively, the
material element 426 may be divided into a plurality of
regions having concentric circular patterns having the
optical axis as the center, and the passing light
amounts of the divided regions may be independently
15 adjusted.

 In this embodiment, the two material elements 425
and 426 are integrally formed on the light incident
surface 424a and the light exit surface 424b of the
transparent substrate 424. However, the present
20 invention is not limited to this. For example, the
material elements 425 and 426 may be arranged at
different positions as in the 19th embodiment.
(23rd Embodiment)

 Fig. 47 is a schematic sectional view of the 23rd
25 embodiment wherein the present invention is applied to
a video camera. The same reference numerals in Fig. 47
denote the same parts as in Fig. 42.

1 In this embodiment, a difference from the 19th
embodiment described above is that material elements
are formed on a plurality of surfaces of light incident
surfaces and light exit surfaces of optical members
5 constituting the photographing optical system 1, such
as a plurality of lenses, an optical lowpass filter
437, a protection glass for protecting the image pickup
element 10, and the like. Other arrangements and
optical effects are substantially the same as those in
10 the 19th embodiment described above.

More specifically, in this embodiment, the
material element 9 is formed on the light exit surface
of the stationary lens 1c, and the material element 401
is formed on the light incident surface of the optical
15 lowpass filter 437. In addition to the same effect as
in the 19th embodiment described above, a light amount
adjustment device can be rendered compact, and the
entire optical system can also be rendered compact.

20 In each of the above embodiments, the present
invention is applied to a video camera. However, the
present invention is not limited to the video camera,
but may be similarly applied to any other optical
systems such as an optical system of a still camera
using a silver chloride film as in the above
25 embodiments.

According to the above embodiments, when a
plurality of material elements capable of arbitrarily

1 adjusting the transmission factor are arranged in the
optical path of the optical system, as described above,
an optical system having a compact light adjustment
device, which can obtain a wider light amount
5 adjustment range by a simple arrangement, and can
obtain a sufficient iris effect, can be realized.
(24th Embodiment)

The 24th embodiment according to the present
invention will be described below.

10 As described above, in recent years, in order to
realize a compact optical system, it has been proposed
that the transmission light amount of the optical
system is adjusted using a material element such as a
liquid crystal element, an electrochromic (EC) element,
15 or the like in place of an iris device for mechanically
adjusting the aperture area of an iris aperture
portion. When the transmission light amount of the
optical system is adjusted using an iris device
consisting of the material element, there have been
20 proposed a method wherein a material element is
arranged in concentric circular patterns having the
optical axis as the center, and light
transmission/shielding states of these patterns are
independently controlled to adjust the area of the iris
25 aperture portion, thereby making the amount of light
transmitted through the optical system and reaching a
photoelectric conversion element constant; and a method

1 wherein when the incident light amount to the optical
system is small, the light transmission factor of a
material element is increased, and when the light
incident amount to the optical system is large, the
5 light transmission factor of the material element is
decreased, thereby making the amount of light reaching
the photoelectric conversion element constant.

However, a meter iris used in the iris device for
mechanically adjusting the iris aperture area in a
10 conventional video camera requires a long period of
time when the iris aperture area changes from a "0"
state (close state) to a full-aperture state (open
state), and vice versa. When the amount of light
incident on a video camera optical system changes at a
15 speed beyond the aperture area adjustment speed of the
iris device, the video camera suffers from an over or
under exposure amount. For example, when a user
quickly goes outdoor from an indoor photographing
state, an over exposure amount may often be
20 instantaneously obtained.

Even when the exposure amount of the video camera
is adjusted using the material element, since a change
in transmission factor of the material element also
requires a long period of time, an under or over
25 exposure state may occur depending on the photographing
condition as in the iris device for mechanically
adjusting the aperture area. In particular, at a low

1 temperature, since the light transmission factor change
speed of the material element is considerably lowered,
an increase in the frequency of occurrence of under or
over exposure states of the video camera poses a
5 serious problem.

This embodiment has as its object to provide a
video camera, which can perform proper exposure amount
control free from an under or over exposure state even
when the amount of light incident on an optical system
10 changes quickly.

In order to achieve the above object, according to
this embodiment, there is provided a video camera,
which has an optical system for forming an object image
on an image pickup element, and transmission light
amount adjustment means, arranged in an optical path of
15 the optical system, for adjusting the transmission
light amount, comprising light accumulation time
adjustment means for adjusting a light accumulation
time of the image pickup element, and exposure amount
control means for, when a change speed of the amount of
20 light incident on the optical system becomes larger
than a light amount change speed corresponding to an
adjustment limit of the transmission light amount
adjustment means, changing the light accumulation time
25 of the image pickup element until exposure amount
adjustment by the transmission light amount adjustment
means is enabled.

1 Furthermore, the video camera further comprises
gain adjustment means for adjusting a gain of a video
signal, and the gain adjustment means can be operated
together with the exposure amount control means.

5 In order to achieve the above object, there is
also provided a video camera, which has an optical
system for forming an object image on an image pickup
element, and a material element, arranged in an optical
path of the optical system, for adjusting the
10 transmission light amount, comprising gain adjustment
means for adjusting a gain of a video signal, and
exposure amount control means for changing the gain of
the video signal in addition to the transmission light
amount adjustment of the material element until
15 exposure amount adjustment by the material element
alone is enabled, under a condition that a change speed
of the amount of light incident on the optical system
becomes larger than the light amount change speed
corresponding to an adjustment light of the material
20 element.

 On the other hand, the video camera may comprise
light accumulation time adjustment means for adjusting
a light accumulation time of the image pickup element,
and the light accumulation time adjustment means can
25 adjust the light accumulation time of the image pickup
element together with the exposure amount control
means.

1 With the above-mentioned means, the exposure
amount can be corrected by temporarily adjusting the
light accumulation time of the image pickup element or
the gain of the video signal. Even when the aperture
5 area adjustment speed of an iris mechanism cannot
follow a quick change in amount of light incident on
the optical system, such a problem can be temporarily
compensated for. Therefore, even when the amount of
light incident on the optical system changes quickly,
10 proper exposure amount control can be performed, and a
high-quality image can be obtained.

 Fig. 48 is a schematic sectional view showing a
video camera according to the 24th embodiment of the
present invention. Since the circuit arrangement of
15 this embodiment is the same as that shown in the block
diagram of Fig. 2 in the first embodiment, and
operation control is the same as that shown in the flow
chart of Fig. 4, a detailed description thereof will be
omitted.

20 Referring to Fig. 48, a photographing optical
system is constituted by a focus lens 1a, zoom lenses
1b, and a stationary lens 1c. The focus lens 1a is
held by a focus lens holding frame 2, which has a gear
portion 2a. A stationary portion 3 is threadably
25 engaged with the focus lens holding frame 2.
Furthermore, a cam cylinder 4 has a cam groove for
determining the positions of the zoom lenses 1b, and is

1 rotatably held by the stationary portion 3. The zoom
lenses 1b are held by lens frames 5 and 6.

5 The focus lens holding frame 2 is pivoted by a
focus motor 7. A gear 7a attached to the rotational
shaft of the motor 7 is engaged with the gear portion
2a. The cam cylinder 4 is pivoted by a zoom motor 8.
A gear 8a is attached to the rotational shaft of the
motor 8. Note that the gear 8a is engaged with a gear
portion 4a of the cam cylinder 4. A galvano iris 500
10 is used for adjusting the transmission light amount of
the photographing optical system.

15 An image pickup element 10 employs a photoelectric
conversion element such as a CCD. The photographing
optical system has an optical axis 11. An electronic
viewfinder 12 has an eyepiece lens 13. Furthermore,
the camera includes a power switch 14, and a zoom
operation member 15. The camera also includes a camera
control circuit 21, and a recording unit 18 and a power
source 19, which are electrically connected to the
20 camera control circuit 21. The camera control circuit
21 is electrically connected to the focus motor 7, the
zoom motor 8, the galvano iris 500, the image pickup
element 10, the electronic viewfinder 12, the power
switch 14, and the zoom operation member 15. Note that
25 an effective light beam 16 is indicated by an alternate
long and two short dashed line.

1 An exposure amount control operation will be
described below with reference to Figs. 49A and 49B.
Fig. 49B shows processing following Fig. 49A.

5 When the exposure amount adjustment operation is
started, the light accumulation time of the image
pickup element (CCD) 10 is set in a standard state
(S401). In this state, if the incident light amount on
the image pickup element 10 is proper (S402), the
aperture size of the galvano iris 500 is maintained
10 (S403). However, if the incident light amount on the
image pickup element 10 is too much (S404), an iris
closing operation of the galvano iris 500 is started
(S405, S406). At this time, if the excess amount of
the incident light amount on the image pickup element
15 10 decreases (S407), light amount adjustment using the
galvano iris 500 is continued. However, if the excess
amount does not change or increases, the light
accumulation time of the image pickup element 10 is
gradually shortened (S408, S409) in addition to the
20 light amount adjustment using the galvano iris 500, so
that the exposure amount approaches a proper value.
When the incident light amount reaches or becomes close
to the proper exposure amount (S410, S411), the light
accumulation time of the image pickup element 10 is
25 gradually prolonged (S412), and is then restored to the
standard state (S413).

1 When the incident light amount on the image pickup
element 10 runs short (S404, S414), an iris opening
operation of the galvano iris 500 is started (S415).
If the shortage amount of the incident light amount on
5 the image pickup element 10 decreases, the light amount
adjustment using the galvano iris 500 is continued.
However, if the shortage amount does not change or
increases (S416), the light accumulation time of the
image pickup element 10 is prolonged up to a limit
10 value (S417, S418, S419) in addition to the light
amount adjustment using the galvano mirror 9, so that
the exposure amount approaches a proper value. When
the incident light amount reaches or becomes close to a
proper exposure amount (S420), the light accumulation
15 time of the image pickup element 10 is gradually
shortened (S421, S422), and is restored to the standard
state. When the exposure amount runs short (S423), it
is checked if the light accumulation time is equal to
or larger than a limit value (S419). If it is
20 determined that the light accumulation time is equal to
or larger than a limit value, the light accumulation
time is fixed at a limit value (S424).

 Figs. 50A and 50B are flow charts showing the
second example of an exposure amount control operation.
25 Although the flow chart of Fig. 50A is followed by the
flow chart of Fig. 50B, since the flow chart of
Fig. 50B is the same as that of Fig. 49B, a detailed

1 description thereof will be omitted. Also, since steps
of executing the same processing as in Fig. 49A are
denoted by the same reference numerals in the flow
chart of Fig. 50A, a repetitive description thereof
5 will be avoided.

The gain of the image pickup element 10 is set in
a standard state (S601), and the light accumulation
time of the image pickup element 10 is set in the
standard state (S401). In this state, if the incident
10 light amount on the image pickup element 10 is proper,
the aperture size of the galvano iris 500 is maintained
(S602). Furthermore, gain adjustment of a video signal
is stopped (S603), and the gain of the video signal is
set in the standard state (S604). Thereafter, the flow
15 returns to step S401, and the subsequent processing is
repetitively executed. If it is determined in step
S402 that the incident light amount is improper, it is
checked in step S404 if the incident light amount is
too much, as has been described above with reference to
20 Fig. 49A. If it is determined in step S404 that the
incident light amount is too much, processing in steps
S405 to S407 is executed. If it is determined in step
S407 that M does not decrease, adjustment of gain
reduction of the video signal is started, and the flow
25 continues to node A in Fig. 49B. Similarly, if it is
determined in step S404 that the incident light amount
runs short, processing in steps S414 to S416 is

1 executed. If it is determined in step S416 that N does
not decrease, adjustment of gain increment of the video
signal is started, and the flow continues to node ④ in
Fig. 49B. Since processing in Fig. 50B is the same as
5 that shown in Fig. 49B, a detailed description thereof
will be omitted.

Fig. 51 is a schematic sectional view showing
another arrangement of a video camera according to the
present invention. Since the same reference numerals
10 in Fig. 51 denote the same parts as in Fig. 48, a
repetitive description thereof will be avoided here.
Also, since the circuit block diagram showing a control
system of this embodiment, and the flow chart showing
the operation of the control circuit are the same as
15 those in Figs. 2 and 4 of the first embodiment, a
detailed description thereof will be omitted.

This embodiment is characterized in that a
material element 501 comprising, e.g., an
electrochromic (EC) element, a liquid crystal element,
20 or the like capable of adjusting the transmission light
amount is arranged in the optical path of the
photographing optical system. The material element 501
is electrically connected to the camera control circuit
21.

25 The exposure amount control operation of the
embodiment shown in Fig. 51 will be described below
with reference to the flow charts of Figs. 52A and 52B

- 1 (for explaining the exposure amount control operation).
Although processing in Fig. 52A is followed by
processing shown in Fig. 52B, the processing shown in
Fig. 52B is the same as that in Fig. 49B, a description
5 thereof will be omitted. Since the same reference
numerals in Figs. 52A and 52B denote the same steps as
in Figs. 49A and 49B, a repetitive description thereof
will be avoided here.

- When the light amount adjustment operation is
10 started, the light accumulation time of the image
pickup element 10 is set in the standard state (S401).
In this state, it is checked if the incident light
amount on the image pickup element 10 is proper (S402).
If it is determined that the incident light amount is
15 proper, the current light transmission factor (or light
transmission amount) of the material element 501 is
maintained (S801), and the flow returns to step S401.
However, if the incident light amount on the image
pickup element 10 is too much, processing for
20 increasing the light transmission factor of the
material element 501 is executed in step S404 and
subsequent steps.

- In this case, if the excess amount of the image
pickup element 10 decreases (S404), light amount
25 adjustment using the material element 501 is continued.
However, if the excess amount does not change or
increases, the light accumulation time of the image

- 1 pickup element 10 is shortened in addition to the light
amount adjustment using the material element 501, so
that the exposure amount approaches a proper value
(S405, S802, S407). When the incident light amount
5 reaches or becomes close to a proper exposure amount,
the light accumulation time of the image pickup element
10 is prolonged, and is restored to the standard state.

- On the other hand, when the incident light amount
on the image pickup element 10 runs short, an operation
10 for decreasing the light transmission factor of the
material element 501 is executed (S414, S803, S416).
At this time, when the shortage amount of the incident
light amount decreases, light amount adjustment using
the material element 501 is continued. However, when
15 the shortage amount does not change or increases, the
light accumulation time of the image pickup element 10
is prolonged up to its limit value in addition to the
light amount adjustment using the material element 501,
so that the exposure amount approaches a proper value.
20 When the light incident amount reaches or becomes close
to a proper exposure amount, the light accumulation
time of the image pickup element 10 is shortened, and
is restored to the standard state.

- Fig. 53 is a flow chart showing the second example
25 of exposure amount control processing corresponding to
the embodiment shown in Fig. 51. Since the same
reference numerals in Fig. 53 denote the same steps as

1 in the above-mentioned flow charts, a repetitive
description thereof will be avoided here.

When the exposure amount adjustment operation is
started, the gain of the image pickup element 10 is set
5 in the standard state (S601). In this state, it is
checked if the incident light amount on the image
pickup element 10 is proper (S402). If the incident
light amount is proper, the light transmission factor
(or light transmission amount) of the material element
10 501 is maintained (S901). Furthermore, gain adjustment
of a video signal is stopped (S902), and the gain of
the video signal is set in the standard state (S903).

However, if the incident light amount on the image
pickup element 10 is too much, processing for
15 decreasing the light transmission factor of the
material element 501 is executed in step S404 and
subsequent steps. If the excess amount of the incident
light amount on the image pickup element 10 decreases,
light amount adjustment using the material element 501
20 is continued. However, if the excess amount does not
change or increases (S404), the gain of the video
signal is decreased (S904) in addition to light amount
adjustment using the material element 501 (S405, S406),
so that the exposure amount approaches a proper value.
25 When the incident light amount reaches or becomes close
to a proper exposure amount, the gain of the video
signal is restored to the standard state.

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1 On the other hand, if the incident light amount on
the image pickup element 10 runs short, processing for
increasing the light transmission factor of the
material element 501 is executed. At this time, if the
5 shortage amount of the incident light amount on the
image pickup element 10 decreases, light amount
adjustment using the material element 501 is continued
(S414, S415). However, if the shortage amount does not
change or increases (S416), the gain of the video
10 signal is increased (S905) in addition to light amount
adjustment using the material element 501, so that the
exposure amount approaches a proper value. Then, when
the incident light amount reaches or becomes close to a
proper exposure amount, the gain of the video signal is
15 restored to the standard state.

 Figs. 54A and 54B are flow charts showing the
third example of exposure amount control processing
corresponding to the embodiment shown in Fig. 51.
Since the same reference numerals in Fig. 54A denote
20 the same steps as in the above-mentioned flow charts, a
repetitive description thereof will be avoided here.
More specifically, in the flow chart of Fig. 53, if it
is determined in step S402 that the incident light
amount is not proper, processing in step S404 and
25 subsequent steps is executed, and then, processing in
steps S904 and S905 is executed to perform gain
adjustment of the video signal. Thereafter, the flow

1 returns to step S402. However, in the flow charts
shown in Figs. 54A and 54B of this embodiment, the flow
advances to processing shown in Fig. 54B. The
processing in Fig. 54B is the same as that shown in
5 Fig. 49B, and a detailed description thereof will be
omitted. That is, in Fig. 54B, the light accumulation
time is controlled.

In each of the above embodiments, the light
transmission amount is adjusted by the material element
10 501. In this case, the light transmission amount of
the optical system may be adjusted by changing the
density of the entire material element. Alternatively,
the material element may have a predetermined pattern,
as shown in Fig. 55, and the light transmission amount
15 of the optical system may be adjusted by changing the
transmission factors of the pattern regions, as shown
in Figs. 56A to 56H, or the light transmission amount
of the optical system may be adjusted by independently
controlling the densities of the pattern regions.

20 Also, transmission factor detection means for the
material element 501 may be arranged to detect the
transmission factor or transmission factor change speed
of the material element. When the incident light
amount to the optical system changes at a speed beyond
25 the incident light amount adjustment capacity of the
material element 501, exposure control may be made
using the present invention. Furthermore, when the

- 1 incident light amount to the optical system changes
rapidly, and the material element 501 cannot perform
incident light amount adjustment even after an elapse
of a predetermined period of time, exposure adjustment
5 according to the present invention may be executed.

Moreover, the transmission light amount adjustment
speed of the material element 501 is normally lowered
in a low-temperature environment. For this reason, a
video camera using the material element 501 in
10 transmission light amount adjustment may be provided
with temperature detection means, and when the incident
light amount to the optical system changes quickly in a
low-temperature environment, exposure adjustment
according to the present invention may be executed.

- 15 Since this embodiment has the above-mentioned
arrangement, it can provide the following effects.

A video camera having an optical system for
forming an object image on an image pickup element, and
transmission light amount adjustment means, arranged in
20 an optical path of the optical system, for adjusting a
transmission light amount, comprises light accumulation
time adjustment means for adjusting a light
accumulation time of the image pickup element, and
exposure amount control means for, when the change
25 speed of an incident light amount to the optical system
exceeds a light amount change speed corresponding to an
adjustment limit of the transmission light amount

1 adjustment means, changing the light accumulation time
of the image pickup element until exposure amount
adjustment of the transmission light amount adjustment
means is enabled. Therefore, even when the incident
5 light amount to the optical system changes quickly,
proper exposure amount control can be performed, and a
high-quality image can be obtained.

Since the video camera also comprises gain
adjustment means for adjusting the gain of a video
10 signal, and the gain adjustment means is operated
together with the exposure amount control means, finer
exposure amount control can be realized.

Also, a video camera having an optical system for
forming an object image on an image pickup element, and
15 a material element, arranged in an optical path of the
optical system, for adjusting a transmission light
amount, comprises gain adjustment means for adjusting
the gain of a video signal, and exposure amount control
means for changing the gain of the video signal in
20 addition to transmission light amount adjustment of the
material element, under a condition that a change speed
of the incident light amount to the optical system
exceeds a light amount change speed corresponding to an
adjustment limit of the material element. Therefore,
25 even when the incident light amount to the optical
system changes fast, proper exposure amount control can
be performed, and a high-quality image can be obtained.

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1 Since the video camera also comprises light
accumulation time adjustment means for adjusting the
light accumulation time of the image pickup element,
and the light accumulation time of the image pickup
5 element is adjusted together with the exposure amount
control means, finer exposure amount control can be
realized.

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1 WHAT IS CLAIMED IS:

1. A video camera comprising:
a material element, arranged in a photographing
optical system, for controlling a light transmission
factor or a light transmission amount;
photoelectric conversion means for receiving an
optical image transmitted through said material element
at a position of an imaging plane, and converting the
optical image into an electrical image signal; and
correction means for correcting light transmission
factor wavelength dependency of said material element
in accordance with light transmission factor
characteristics or light transmission amount
characteristics of said material element.
2. A video camera according to claim 1, wherein
said correction means adjusts a correction amount of
the light transmission factor wavelength dependency in
accordance with the light transmission factor or the
light transmission amount of said material element.

- I. 3. A video camera according to claim 1, wherein
~~the correction of said correction means is achieved by~~ *Corrects said change*
auto white-balance control ^{of} ~~for~~ an output signal from
said photoelectric conversion means.

11
a G 4. A ~~video~~ camera according to claim 1, wherein
the ~~correction of~~ ^{by} said correction means ^{corrects said change} is achieved by
changing a sensitivity of said photoelectric conversion
means in accordance with a light wavelength.

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~~Suba~~ 5. A video camera according to claim 1, wherein
the correction of said ~~correction~~ means is achieved by
a filter provided to said photographing optical system
or said photoelectric conversion means.

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~~Suba~~ 6. A ~~video~~ camera according to claim 1, wherein
the ~~correction of~~ ^{by} said correction means ^{corrects said change} is achieved by
arranging another ^{physical} ~~material~~ element capable of
controlling a light transmission factor in said ~~the~~
15 photographing optical system.

15

~~Suba~~ 7. A video camera according to claim 1, wherein
said correction means comprises storage means for
storing the light transmission factor wavelength
20 dependency of said material element or the correction
amount of the light transmission factor wavelength
dependency of said material element.

8. A video camera according to claim 7, wherein
25 said storage means stores a plurality of light
transmission factor wavelength dependencies or a
plurality of correction amounts in accordance with the

1 light transmission factor or the light transmission
amount of said material element.

9. A video camera comprising:

5 a material element, arranged in a photographing
optical system, for controlling a light transmission
factor or a light transmission amount;

photoelectric conversion means for receiving an
optical image transmitted through said material element
10 at a position of an imaging plane, converting the
optical image into an electrical image signal, and
capable of adjusting at least one of a light
accumulation time and a sensitivity; and

exposure amount adjustment means for adjusting the
15 light transmission factor or the light transmission
amount of said material element, and at least one of
the light accumulation time and the sensitivity of said
photoelectric conversion means.

20 10. A video camera according to claim 9, wherein
said exposure amount adjustment means electrically
adjusts the light transmission factor or the light
transmission amount of said material element.

25 11. A video camera according to claim 9, wherein
said exposure amount adjustment means adjusts the light
transmission factor or the light transmission amount of

1 said material element in accordance with incident
light.

12. A video camera according to claim 9, wherein
5 said exposure amount adjustment means comprises storage
means for storing at least one relationship between the
light transmission factor or the light transmission
amount of said material element and the light
accumulation time or the sensitivity of said
10 photoelectric conversion means.

13. A video camera having a photographing optical
system consisting of an optical element such as a
photographing lens, and image pickup means, wherein a
15 material element capable of controlling a light
transmission factor is arranged in one of said optical
element and said image pickup element.

14. A video camera according to claim 13, wherein
20 said material element is formed on said optical
element.

15. A video camera according to claim 13, wherein
said material element is held by an optical element
25 holding member of said photographing optical system.

1 16. A camera, which has a photographing optical
system, a material element, having polarization means,
for controlling a transmission light factor or a
transmission light amount of said photographing optical
5 system, light reflection means, and photoelectric
conversion means arranged on an imaging plane of said
photographing optical system or on a plane optically
equivalent to the imaging plane, comprising: circularly
polarizing light conversion means arranged on a side of
10 the imaging plane of said material element or on a side
of the plane optically equivalent to the imaging plane,
wherein said light reflection means is arranged between
said photoelectric conversion means and said circularly
polarizing light conversion means.

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17. A camera according to claim 16, wherein said
material element and said circularly polarizing light
conversion means are integrally arranged.

20 18. A camera, which has a photographing optical
system, a material element, having polarization means,
for controlling a transmission light factor or a
transmission light amount of said photographing optical
system, light reflection means, and photoelectric
25 conversion means arranged on an imaging plane of said
photographing optical system or on a plane optically
equivalent to the imaging plane, wherein said material

- 1 element is arranged between the imaging plane and said
light reflection means.

19. A video camera, which has a photographing
5 optical system including a material element, having
polarization means, for controlling a light
transmission factor or a light transmission amount, and
an optical lowpass filter, and also has photoelectric
conversion means arranged on an imaging plane of said
10 photographing optical system or on a plane optically
equivalent to the imaging plane, comprising: circularly
polarizing light conversion means arranged on a side of
the imaging plane of said material element or on a side
of the plane optically equivalent to the imaging plane,
15 wherein said optical lowpass filter is arranged between
said photoelectric conversion means and said circularly
polarizing light conversion means.

20. A video camera according to claim 19, wherein
20 said material element and said circularly polarizing
light conversion means are integrally arranged.

21. A video camera, which has a photographing
optical system including a material element, having
25 polarization means, for controlling a light
transmission factor or a light transmission amount, and
an optical lowpass filter, and also has photoelectric

- 1 conversion means arranged on an imaging plane of said
photographing optical system or on a plane optically
equivalent to the imaging plane, wherein said material
element is arranged between said photoelectric
5 conversion means and said optical lowpass filter.

22. A camera, which has a photographing optical
system including a material element capable of
controlling a light transmission factor or a light
10 transmission amount, and also has photoelectric
conversion means arranged on an imaging plane of said
photographing optical system or on a plane optically
equivalent to the imaging plane, wherein said material
element has a filter function of removing near infrared
15 light.

23. A camera, which has a photographing optical
system including a material element capable of
controlling a light transmission factor or a light
20 transmission amount, and also has photoelectric
conversion means arranged on an imaging plane of said
photographing optical system or on a plane optically
equivalent to the imaging plane, wherein said material
element and a filter for removing near infrared light
25 are integrally arranged.

1 24. A video camera, which has a photographing
optical system including a material element capable of
controlling a light transmission factor, and also has
photoelectric conversion means arranged on an imaging
5 plane of said photographing optical system, comprising:
correction means for correcting light transmission
factor wavelength dependency characteristics of said
material element.

10 25. A video camera according to claim 24, further
comprising storage means for storing the light
transmission factor wavelength dependency
characteristics of said material element, which are
obtained when said material element is in a
15 predetermined state.

26. A video camera according to claim 25, wherein
said storage means is storage means for storing a
plurality of light transmission factor wavelength
20 dependency characteristics of said material element,
which are obtained when said material element is in the
predetermined state.

27. A video camera according to claim 25, further
25 comprising temperature detection means, and wherein
said storage means is storage means for storing a
plurality of light transmission factor wavelength

1 dependency characteristics of said material element
under a predetermined temperature condition.

28. A video camera, which has a photographing
5 optical system including a material element capable of
controlling a light transmission factor or a light
transmission amount, and also has photoelectric
conversion means arranged on an imaging plane of said
photographing optical system, wherein when said
10 photoelectric conversion means does not perform a
photoelectric conversion operation, said material
element is set in a light shielding state, a
substantially minimum light transmission factor state,
or a substantially minimum light transmission amount
15 state.

29. A video camera according to claim 28, wherein
when a power switch of said video camera is turned off,
said material element is set in the light shielding
20 state, substantially the minimum light transmission
factor state, or substantially the minimum light
transmission amount state.

30. A video camera according to claim 28, further
25 comprising reproduction means for reproducing a
recorded image, and wherein when said video camera is
set in a reproduction state of the recorded image or in

1 a reproduction mode of the recorded image, said
material element is set in the light shielding state,
substantially the minimum light transmission factor
state, or substantially the minimum light transmission
5 amount state.

31. A video camera according to claim 28, wherein
when said photoelectric conversion means does not
perform a photoelectric conversion operation, voltage
10 application to said material element is not performed.

32. A video camera according to claim 28, wherein
when said photoelectric conversion means stops a
photoelectric conversion operation, said material
15 element is set in the light shielding state,
substantially the minimum light transmission factor
state, or substantially the minimum light transmission
amount state, and thereafter, voltage application to
said material element is stopped.

20

33. A video camera according to claim 31, wherein
when voltage application to said material element is
not performed, said material element is set in the
light shielding state, substantially the minimum light
25 transmission factor state, or substantially the minimum
light transmission amount state.

1 34. A video camera according to claim 32, wherein
when voltage application to said material element is
stopped, the light transmission factor or the light
transmission amount of said material element is held in
5 a state obtained when the voltage application to said
material element is stopped.

35. An optical system having a light amount
adjustment device, which controls a passing light
10 amount by arranging a plurality of material elements
capable of adjusting a transmission factor in an
optical path of an optical system.

36. An optical system according to claim 35,
15 wherein a light transmission region of at least one of
said plurality of material elements is divided into a
plurality of regions, and a transmission factor of at
least one of the divided regions can be adjusted
independently of the other regions.

20 37. An optical system according to claim 36,
wherein said at least one material element divided into
the plurality of regions is arranged near an iris
position of said optical system.

25 38. An optical system according to claim 35,
wherein an optical element on a light incident surface

1 side and a light exit surface side of which said
material elements are arranged is arranged in the
optical path of said optical system.

5 39. An optical system according to claim 38,
wherein said material element is formed on the entire
surface of at least one of the light incident surface
and the light exit surface of said optical element, and
said material element is formed on only a ring-shaped
10 region of a circle having an optical axis as a center
on the other surface.

40. An optical system according to claim 35,
wherein said material element is formed on at least one
15 surface of an optical member constituting said optical
system.

41. An optical system having a light amount
adjustment device, wherein when a plurality of material
20 elements capable of adjusting a transmission factor are
arranged in an optical path of said optical system to
control a passing light amount, a light transmission
region of at least one of said plurality of material
elements is divided into a plurality of regions, and a
25 transmission factor of at least one of the divided
regions can be adjusted independently of the other
regions.

1 42. A video camera, which has an optical system
for forming an image of an object image on an image
pickup element, and transmission light amount
adjustment means, arranged in an optical path of said
5 optical system, for adjusting a transmission light
amount, comprising:

light accumulation time adjustment means for
adjusting a light accumulation time of said image
pickup element; and

10 exposure amount control means for, when a change
speed of an incident light amount to said optical
system exceeds a light amount change speed
corresponding to an adjustment limit of said
transmission light amount adjustment means, changing
15 the light accumulation time of said image pickup
element until exposure amount adjustment of said
transmission light amount adjustment means is enabled.

20 43. A video camera according to claim 42, further
comprising gain adjustment means for adjusting a gain
of a video signal, and wherein said gain adjustment
means operates together with said exposure amount
control means.

25 44. A video camera, which has an optical system
for forming an image of an object image on an image
pickup element, and a material element, arranged in an

1 optical path of said optical system, for adjusting a
transmission light amount, comprising:

gain adjustment means for adjusting a gain of a
video signal; and

5 exposure amount control means for changing the
gain of the video signal until exposure amount
adjustment using said material element alone is enabled
in addition to transmission light amount adjustment
using said material element under a condition that a
10 change speed of an incident light amount to said
optical system exceeds a light amount change speed
corresponding to an adjustment limit of said material
element.

15 45. A video camera according to claim 44, further
comprising light accumulation time adjustment means for
adjusting a light accumulation time of said image
pickup element, and wherein said light accumulation
time adjustment means adjusts the light accumulation
20 time of said image pickup element together with said
exposure amount control means.



1 ABSTRACT OF THE DISCLOSURE

There is disclosed a video camera including a material element, arranged in a photographing optical system, for controlling the light transmission factor or amount, an image pickup element for receiving an optical image transmitted through the material element at the position of an imaging plane, and converting the optical image into an electrical signal, and a correction unit for correcting the light transmission factor wavelength dependency of the material element in accordance with the light transmission factor characteristics or light transmission amount characteristics of the material element.

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FIG. 1

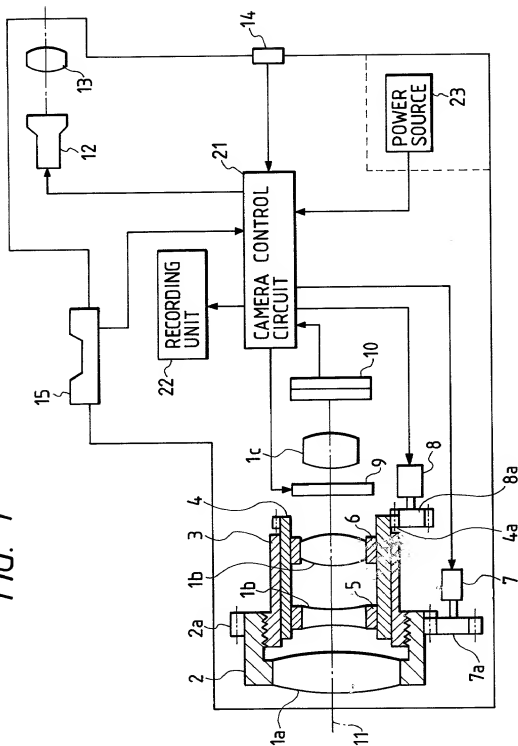
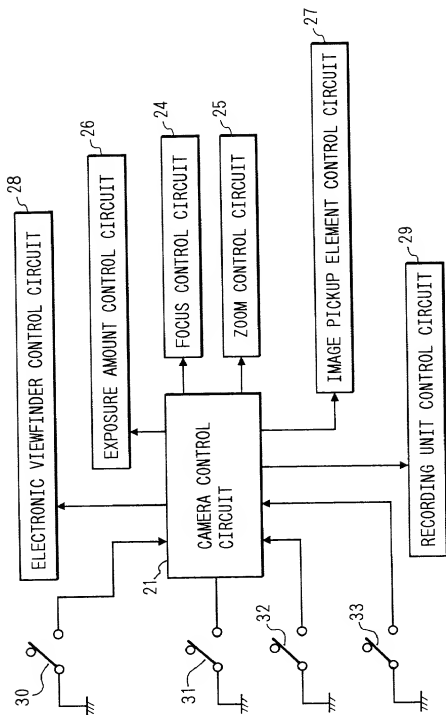


FIG. 2



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FIG. 3

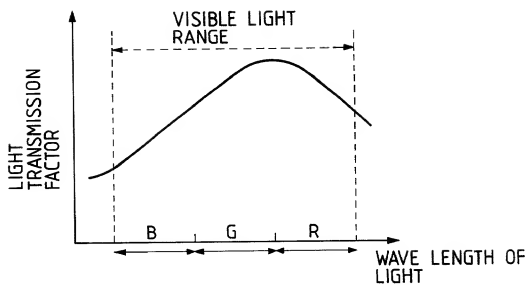


FIG. 7

Mg	G	Mg	G
Cy	Ye	Cy	Ye
Mg	G	Mg	G
Cy	Ye	Cy	Ye

FIG. 4

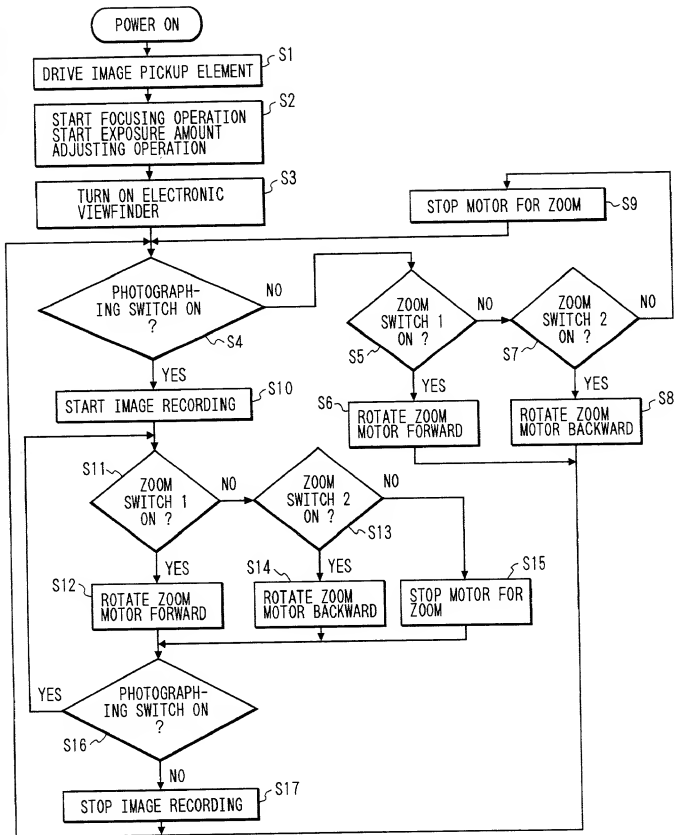


FIG. 5

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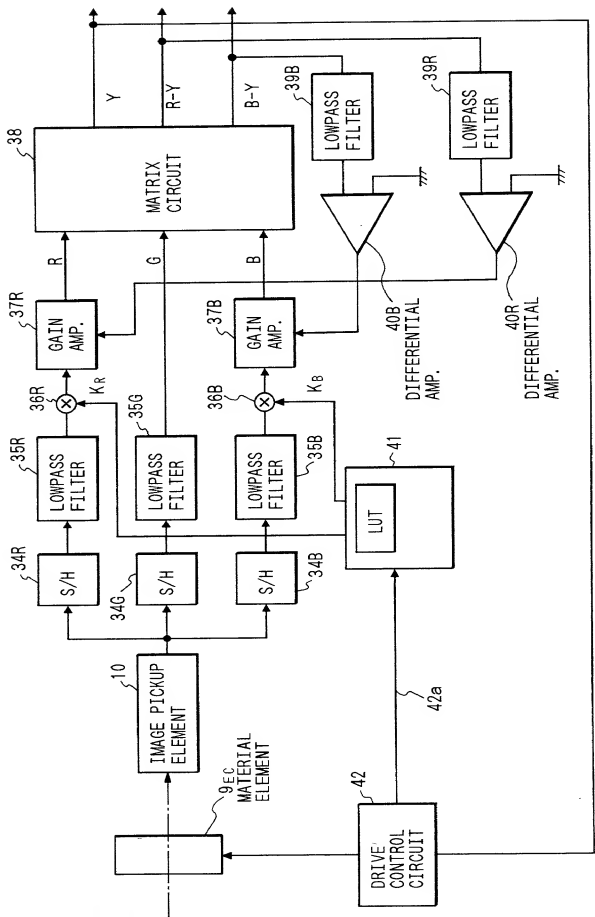
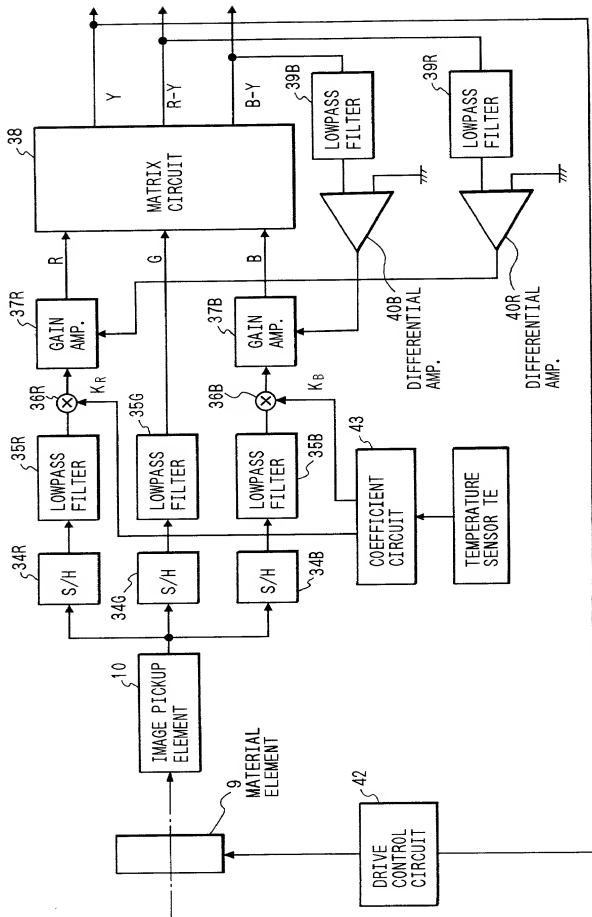


FIG. 6

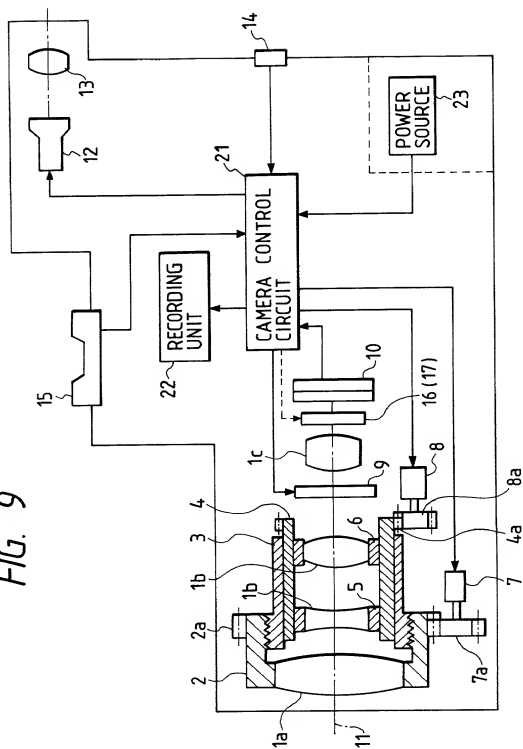


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FIG. 9



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FIG. 8

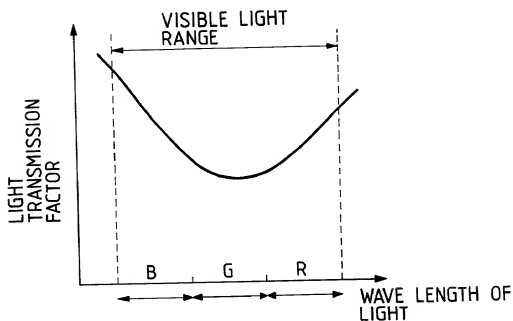
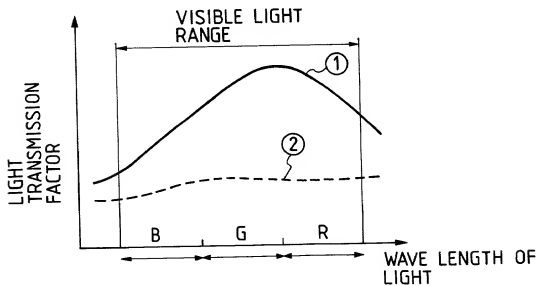
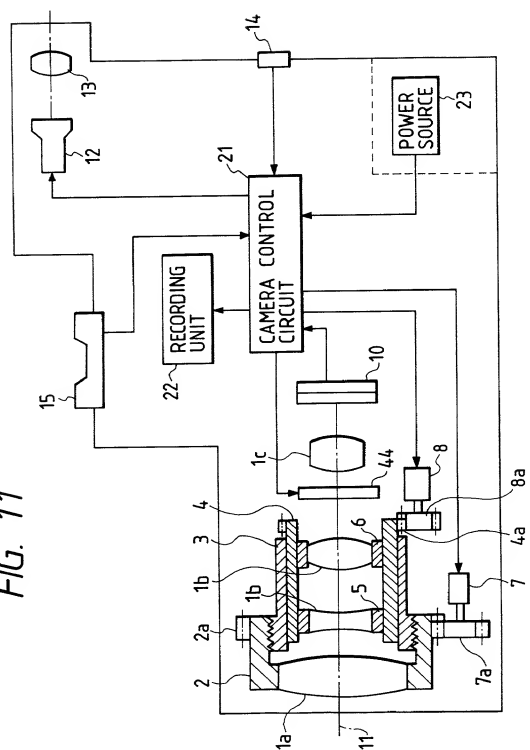


FIG. 10



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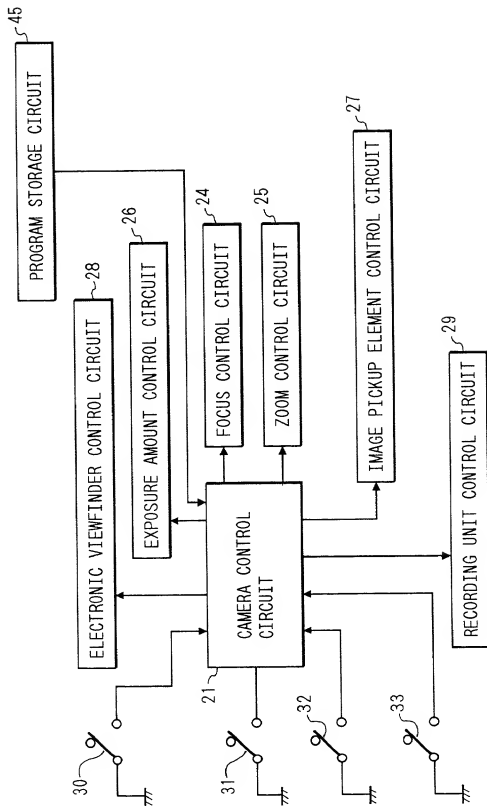
FIG. 11



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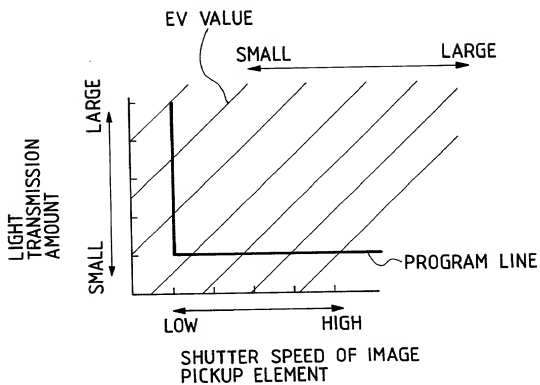
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BY	CLASS
REMARKS	

FIG. 12



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FIG. 13



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FIG. 14A

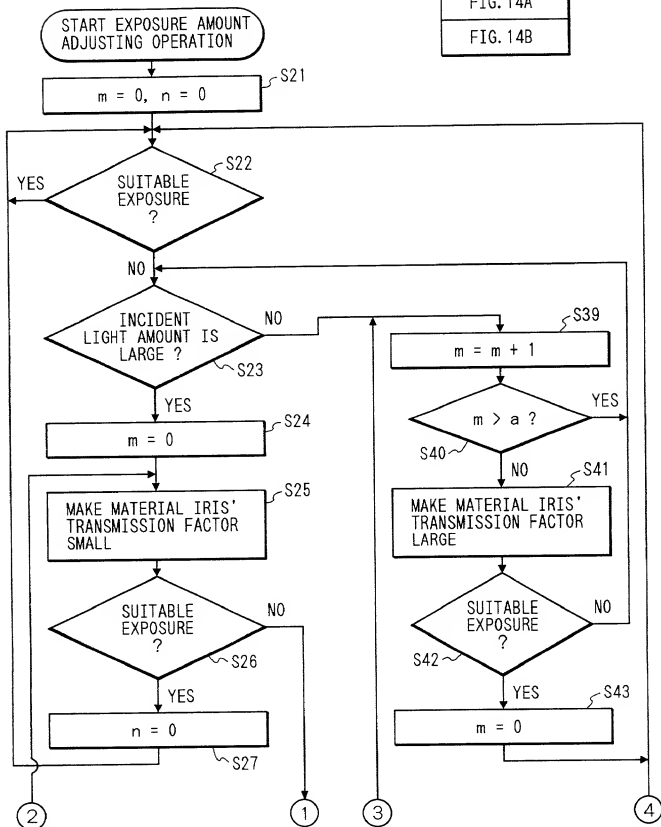
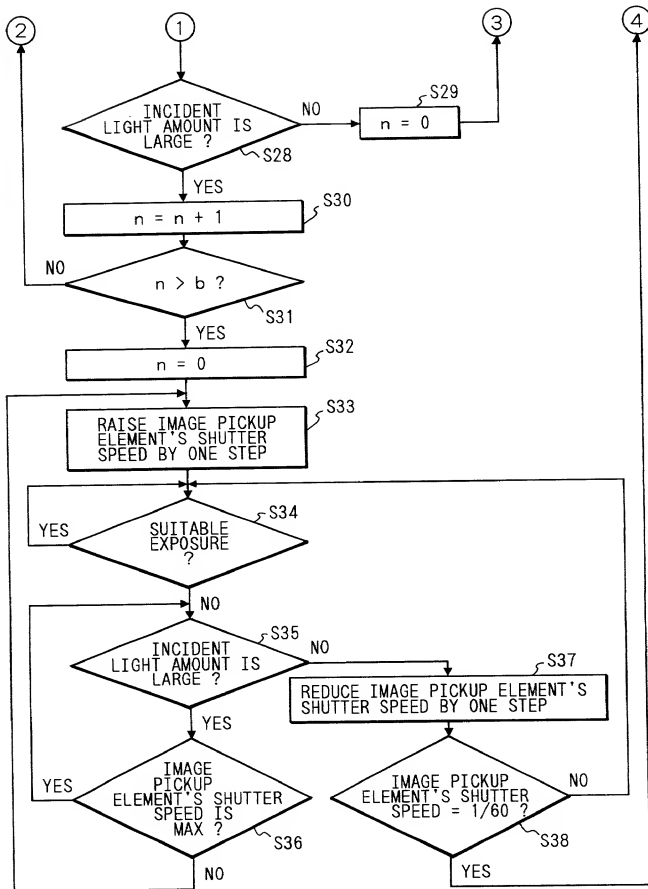


FIG. 14

FIG. 14A
FIG. 14B

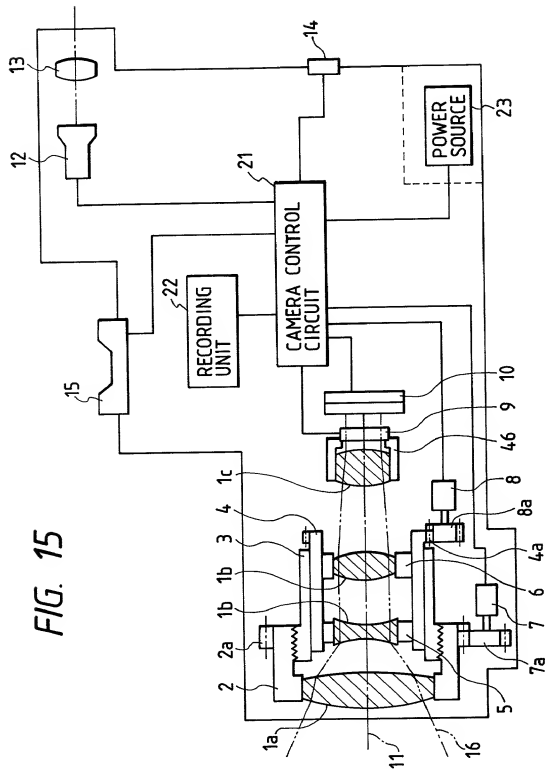
FIG. 14B



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 CLASS _____
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 DRAFTSMAN _____

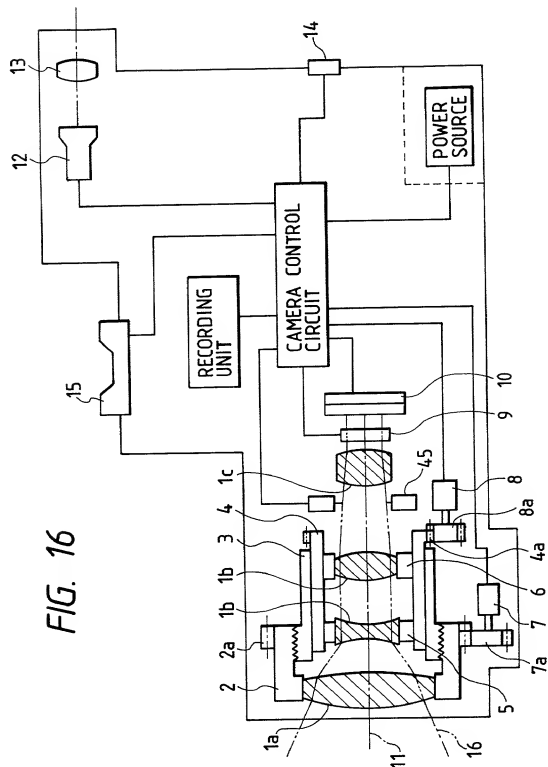
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FIG. 15



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FIG. 16



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FIG. 17

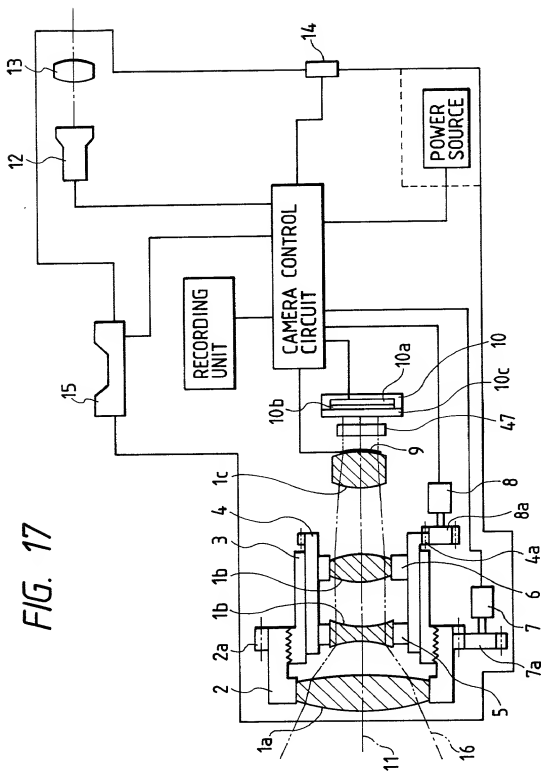
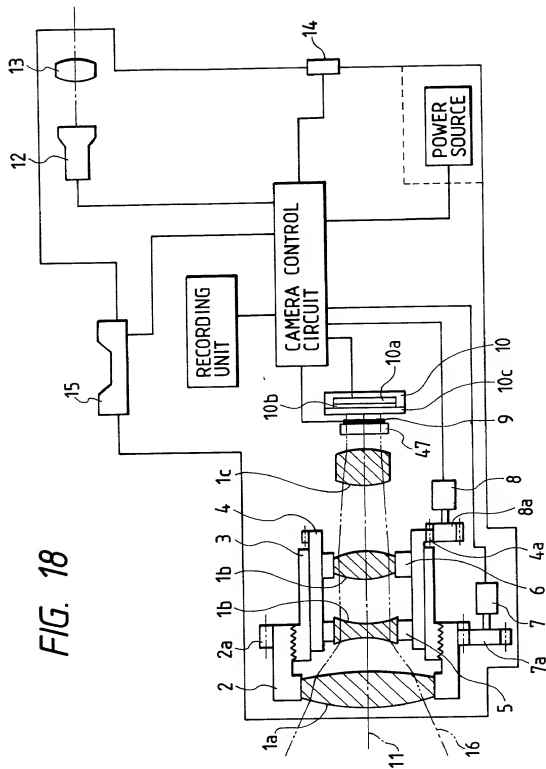


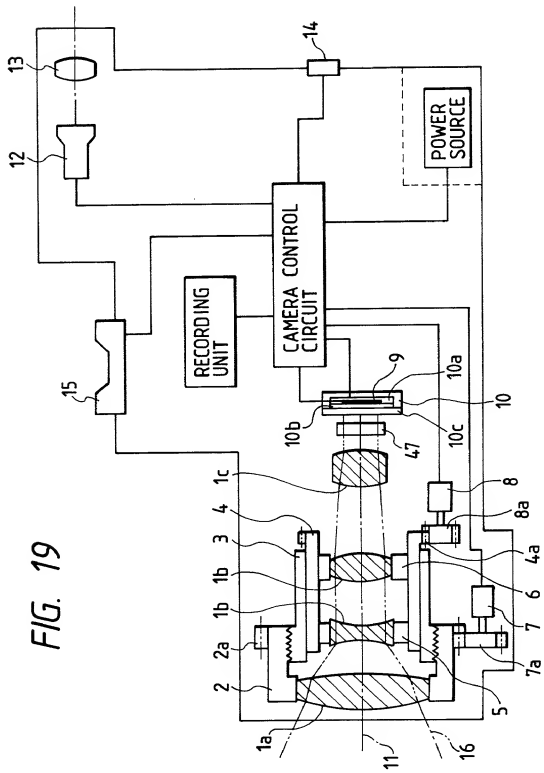
FIG. 18



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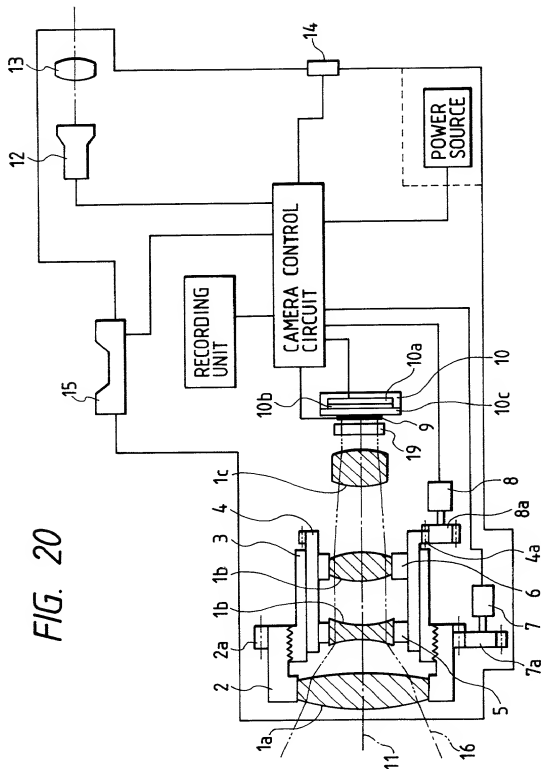
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FIG. 19



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FIG. 20



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FIG. 22

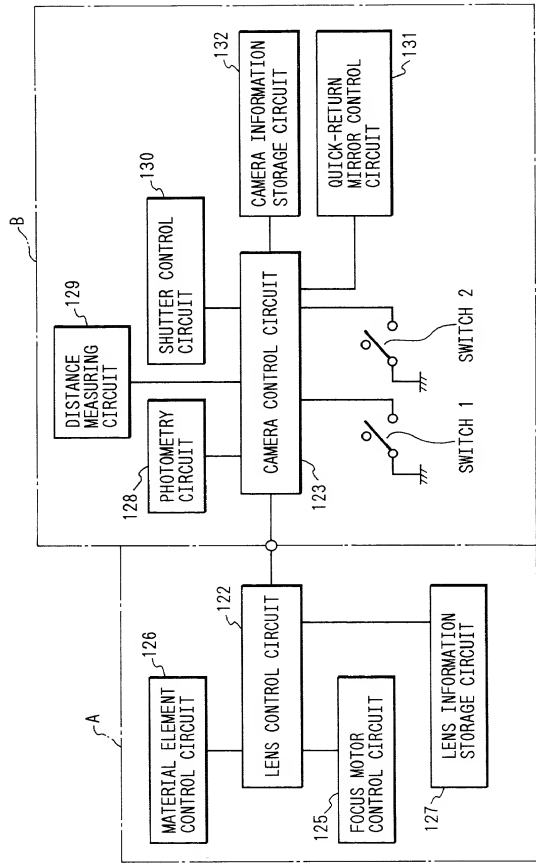
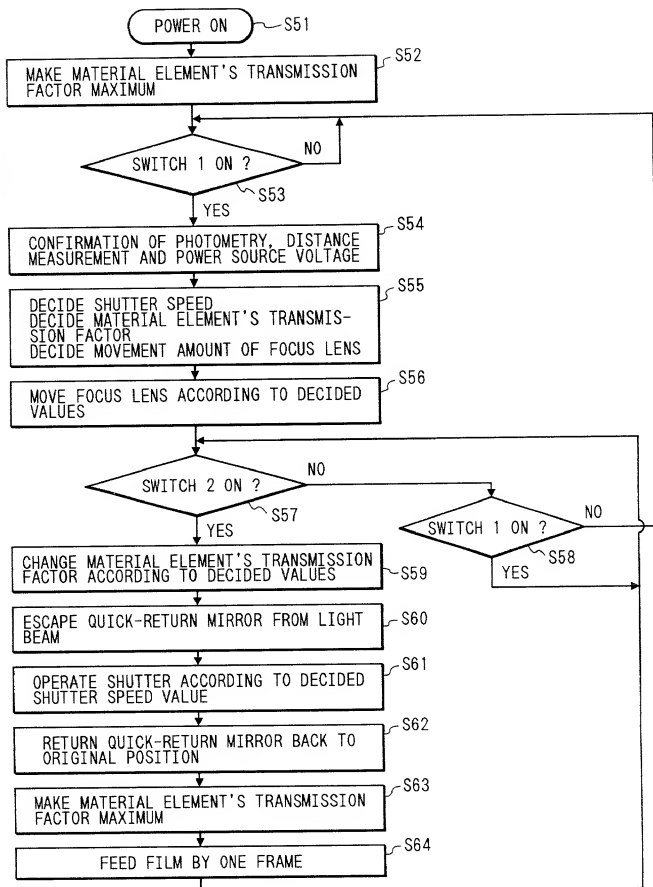


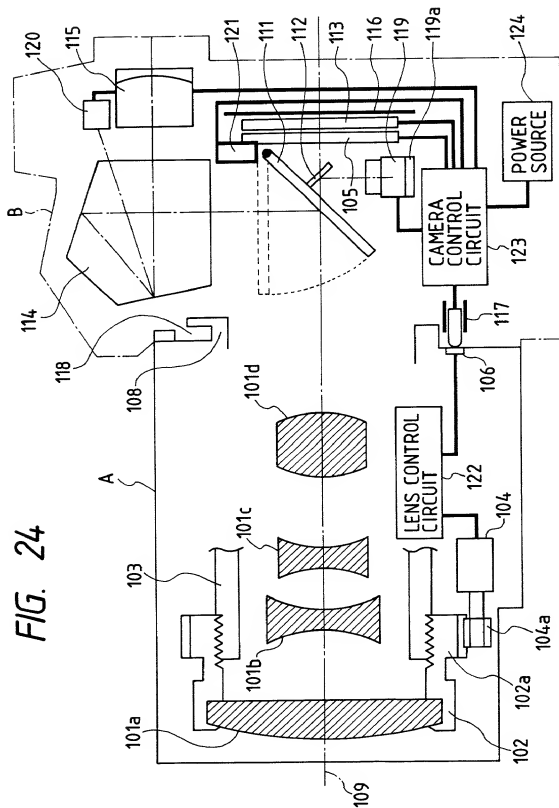
FIG. 23



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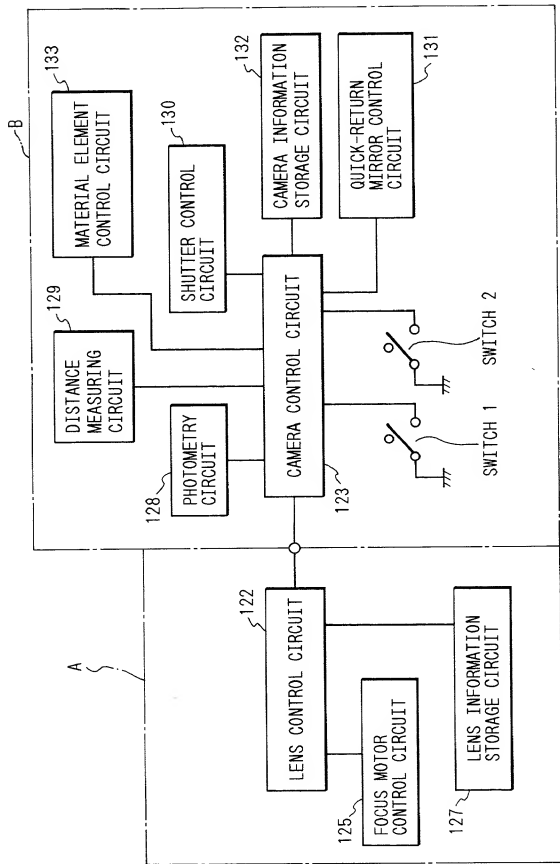
660240-24264883

FIG. 24



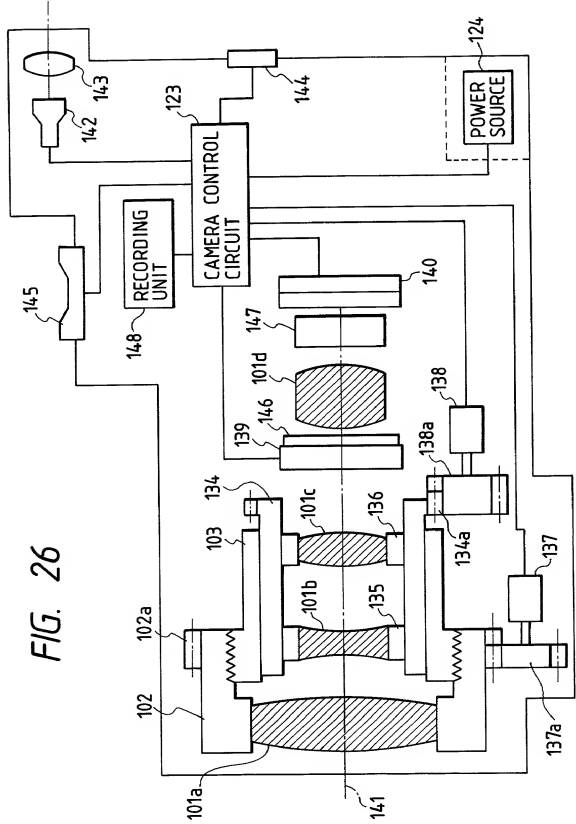
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FIG. 25



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FIG. 26



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 DATES _____
 DRAFTSMAN _____

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FIG. 28

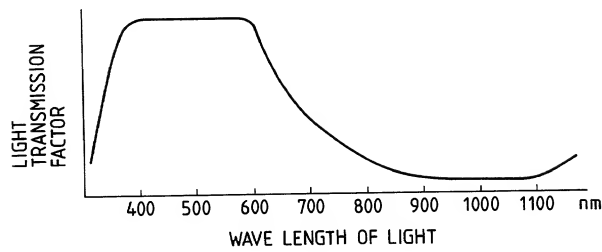


FIG. 29

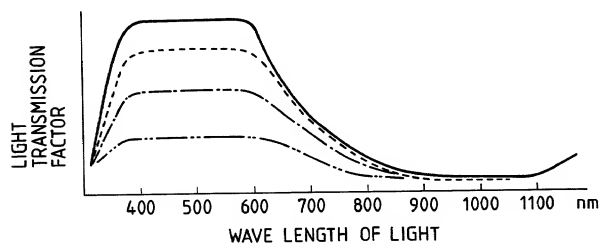
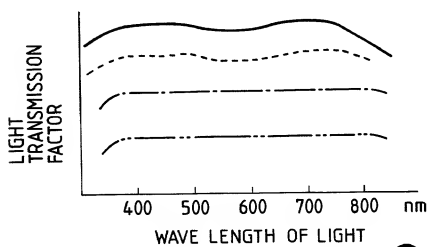


FIG. 30



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FIG. 31

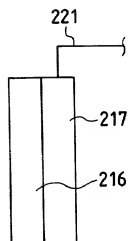


FIG. 32

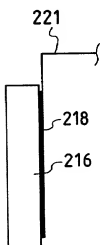


FIG. 33

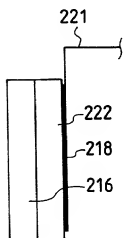


FIG. 34

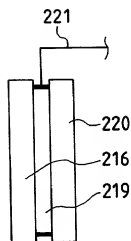
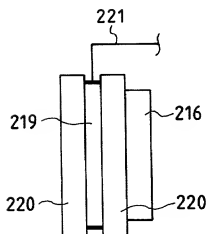
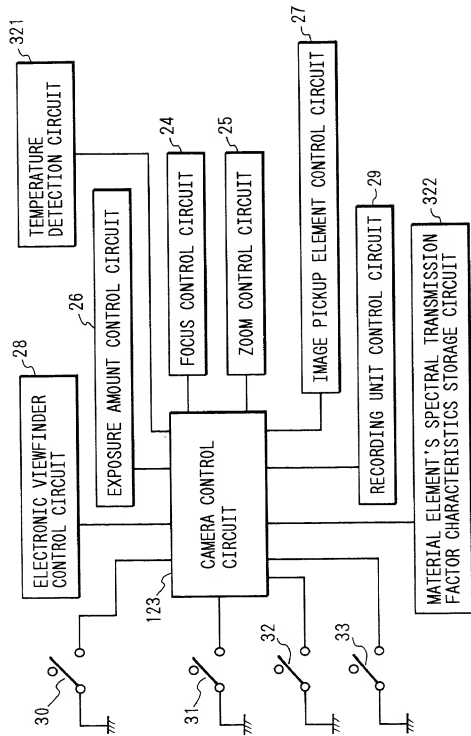


FIG. 35



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FIG. 36



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FIG. 37

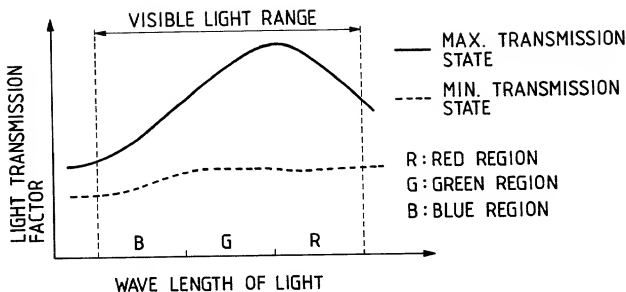


FIG. 38

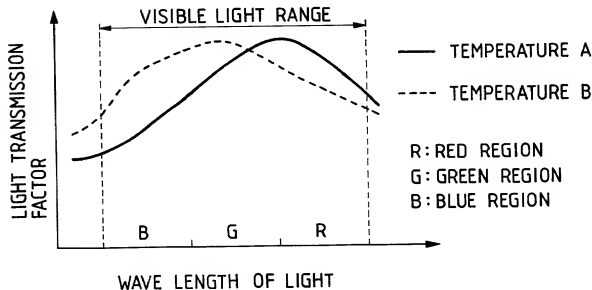
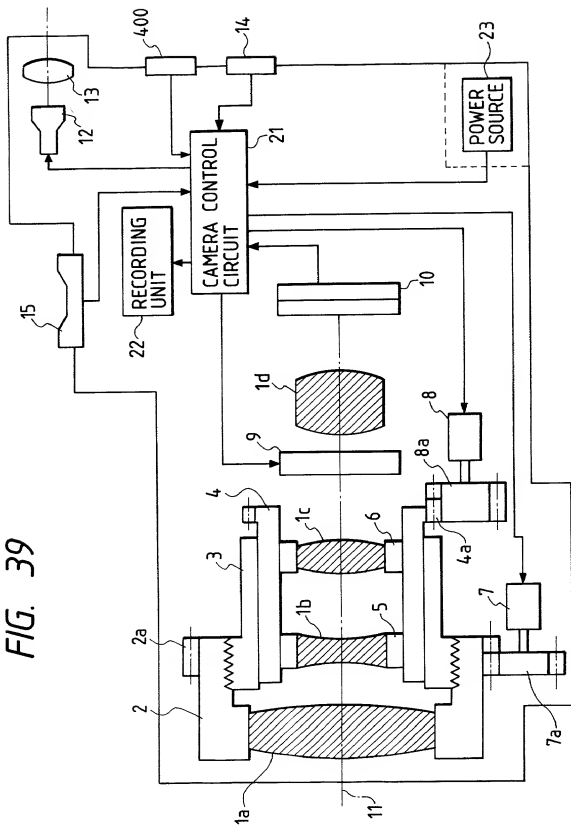
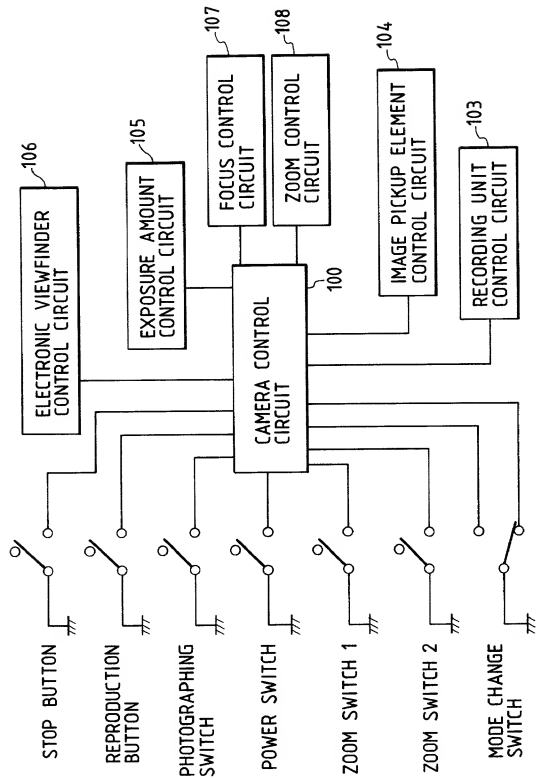


FIG. 39



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FIG. 40



O.C. FIG. 1
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 APPROVED BY 62155A
 46240-2423-1000

FIG. 41A

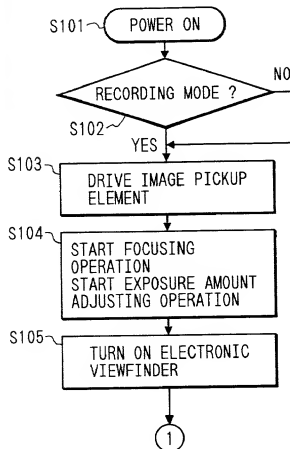
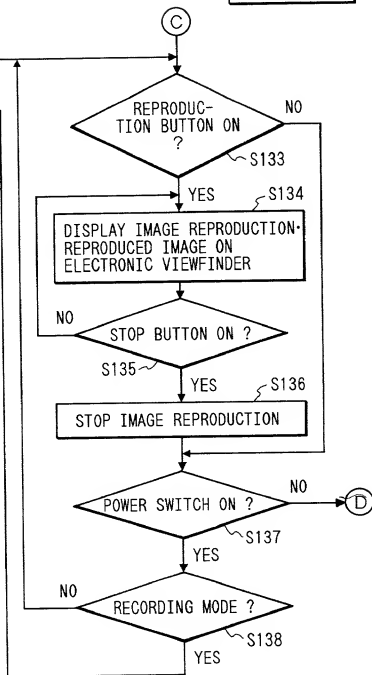


FIG. 41

FIG. 41A

FIG. 41B

FIG. 41C



APPROVED BY CLASS DRAFTSMAN

FIG. 41B

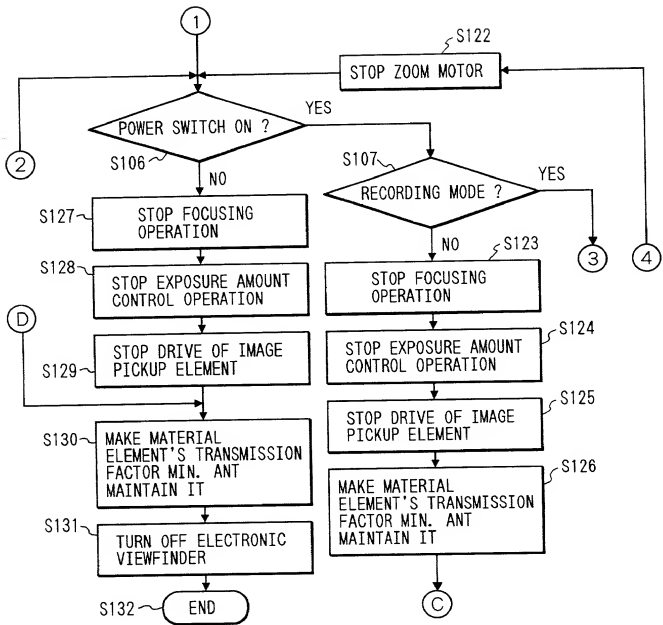
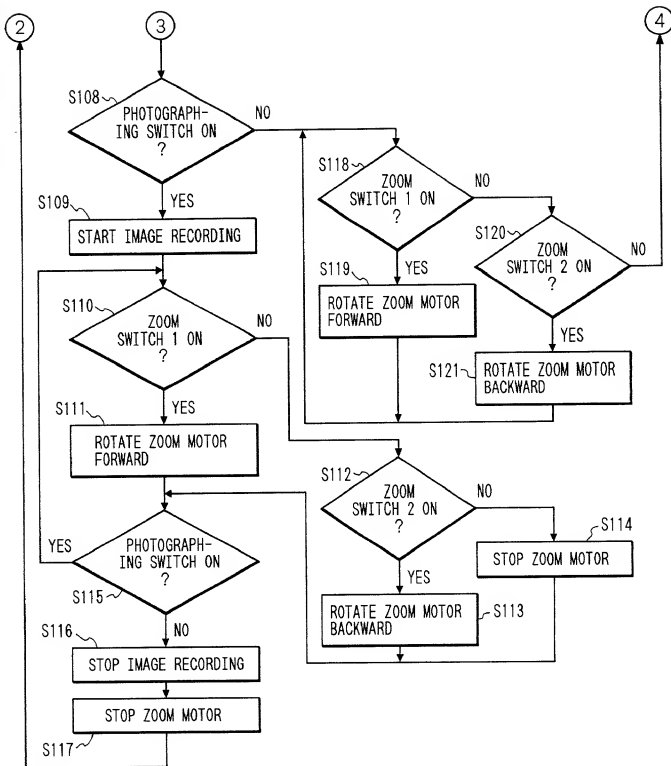


FIG. 41C



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FIG. 42

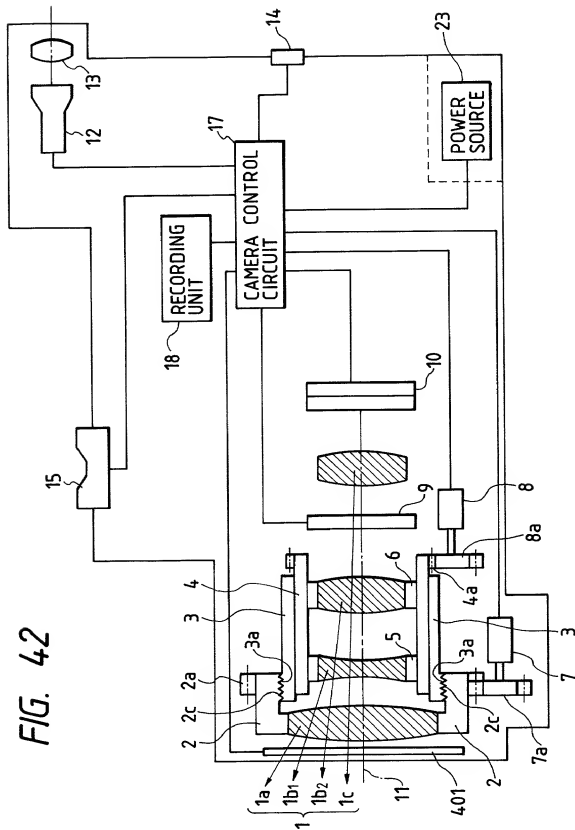


FIG. 43A

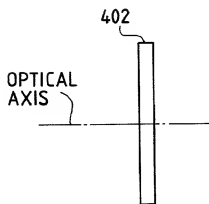


FIG. 43B

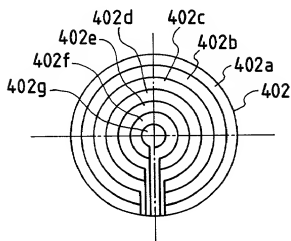


FIG. 45

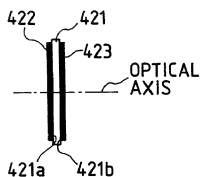


FIG. 46A

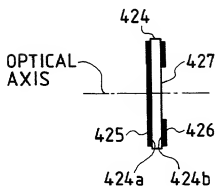
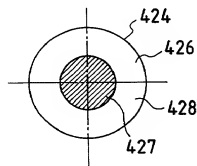
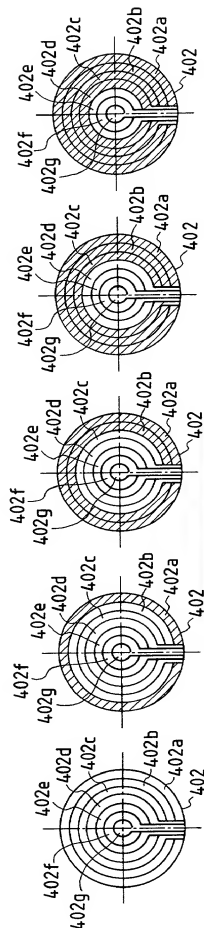


FIG. 46B



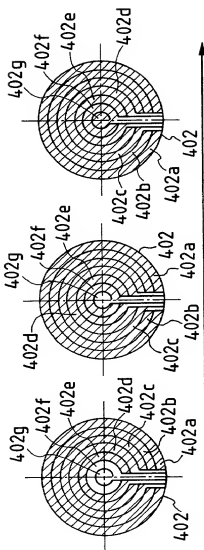
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FIG. 44A FIG. 44B FIG. 44C FIG. 44D FIG. 44E



LARGE TRANSMISSION FACTOR (DEPTH OF FIELD IS SHALLOW)

FIG. 44F FIG. 44G FIG. 44H



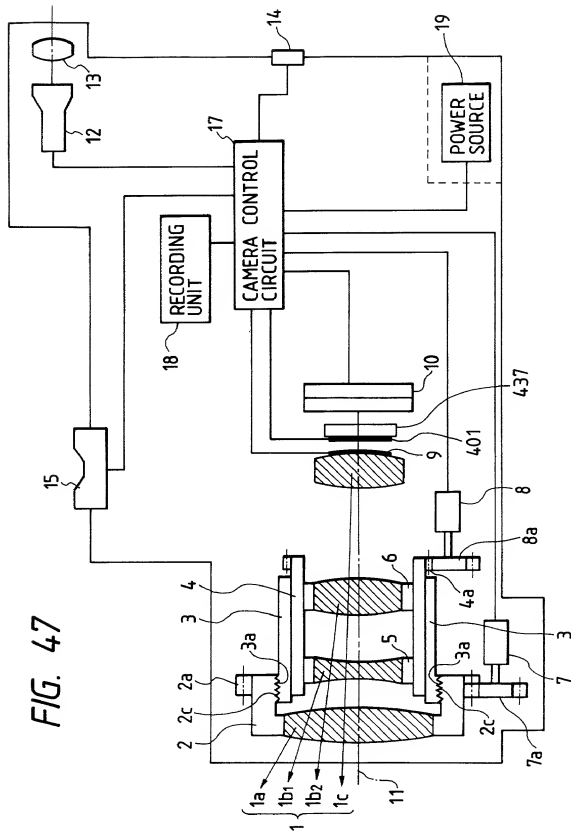
SMALL TRANSMISSION FACTOR (DEPTH OF FIELD IS DEEP)

AREA DENOTES AREA HAVING SMALL TRANSMISSION FACTOR

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APPROVED BY COMMISSION
CLASS CLASSIFICATION
C.G. FIG.

FIG. 47



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FIG. 48

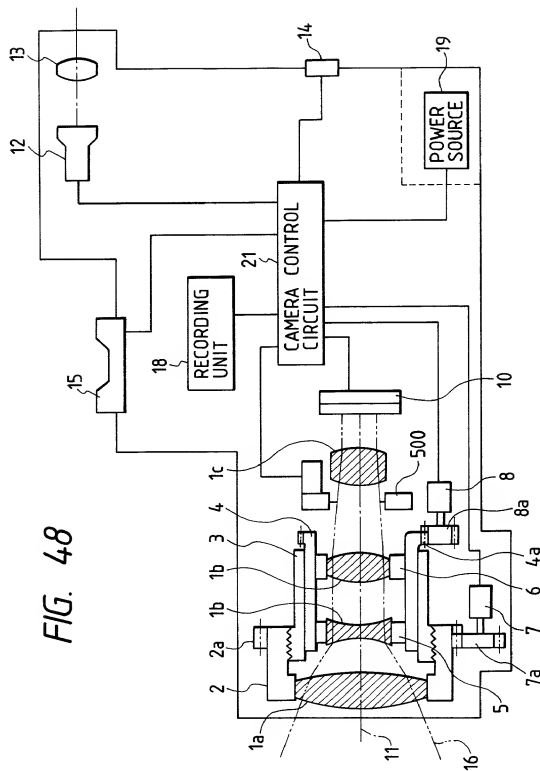


FIG. 49A

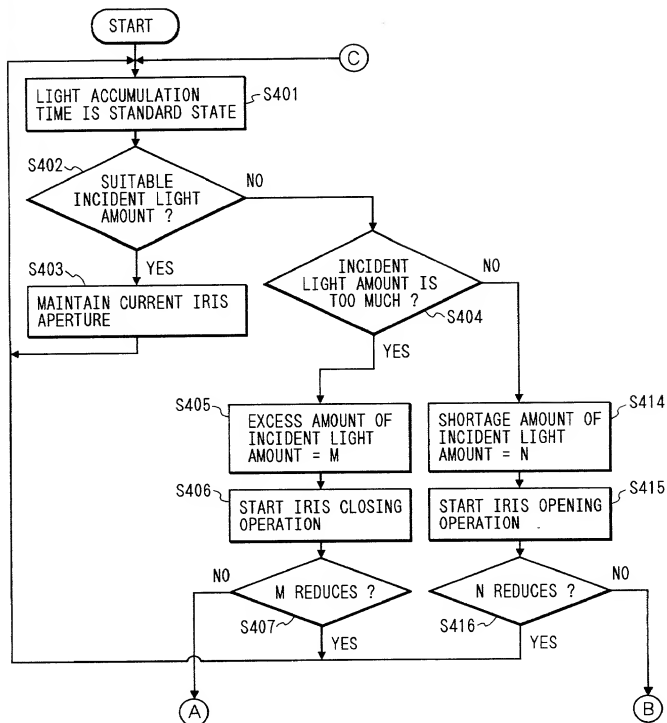


FIG. 49B

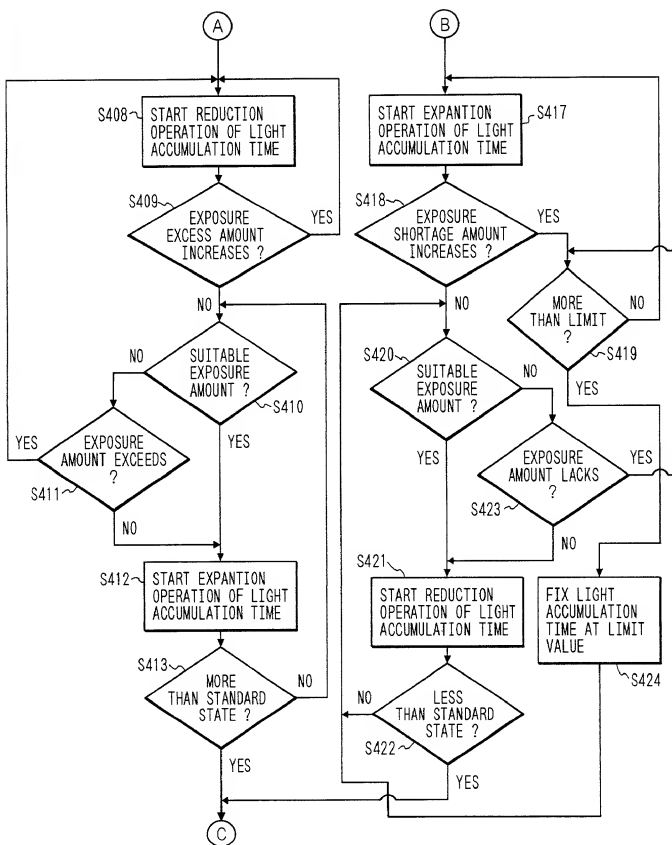
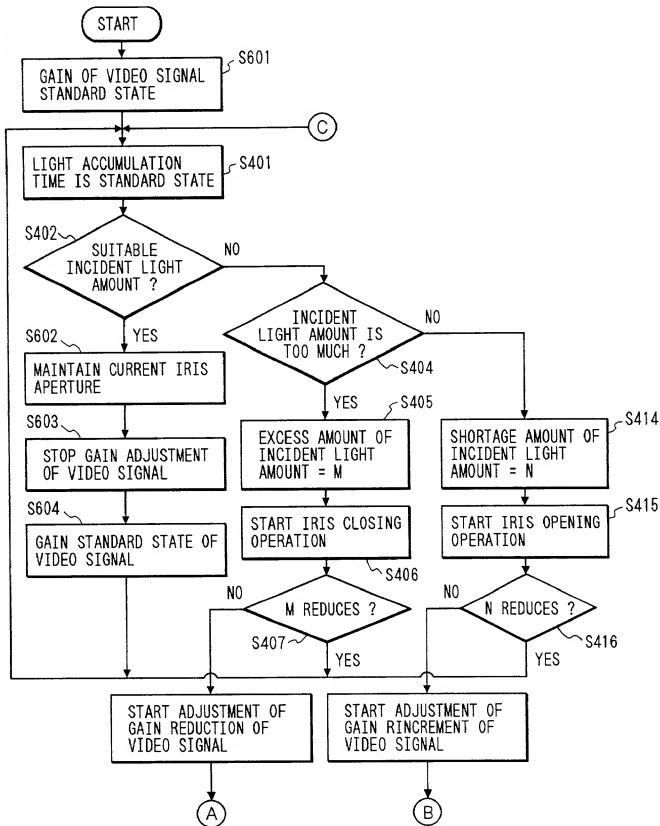
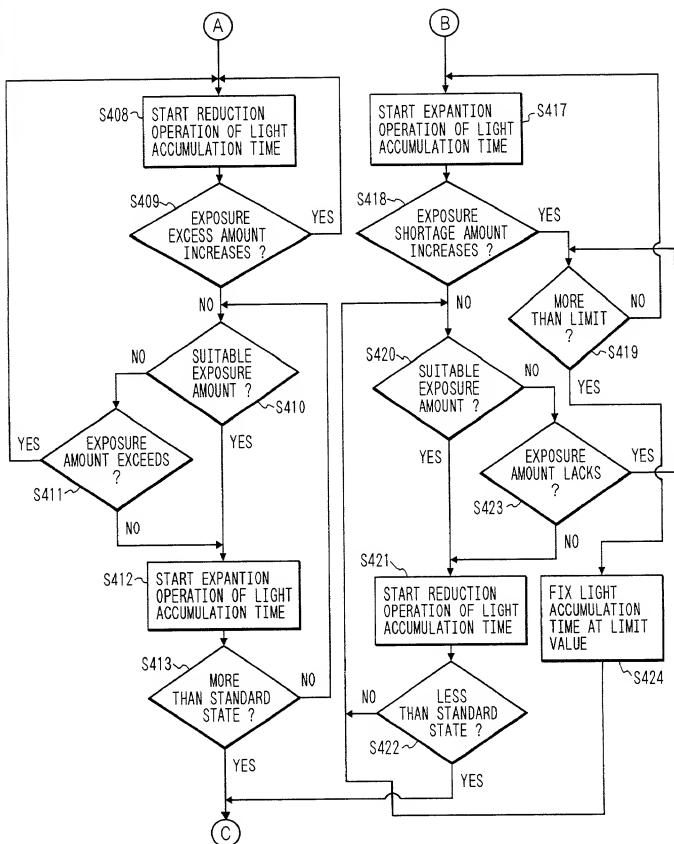


FIG. 50A



0 1 2 3 4 5 6 7 8 9
 10 11 12 13 14 15 16 17 18 19
 20 21 22 23 24 25 26 27 28 29
 30 31 32 33 34 35 36 37 38 39
 40 41 42 43 44 45 46 47 48 49
 50 51 52 53 54 55 56 57 58 59
 60 61 62 63 64 65 66 67 68 69
 70 71 72 73 74 75 76 77 78 79
 80 81 82 83 84 85 86 87 88 89
 90 91 92 93 94 95 96 97 98 99





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FIG. 51

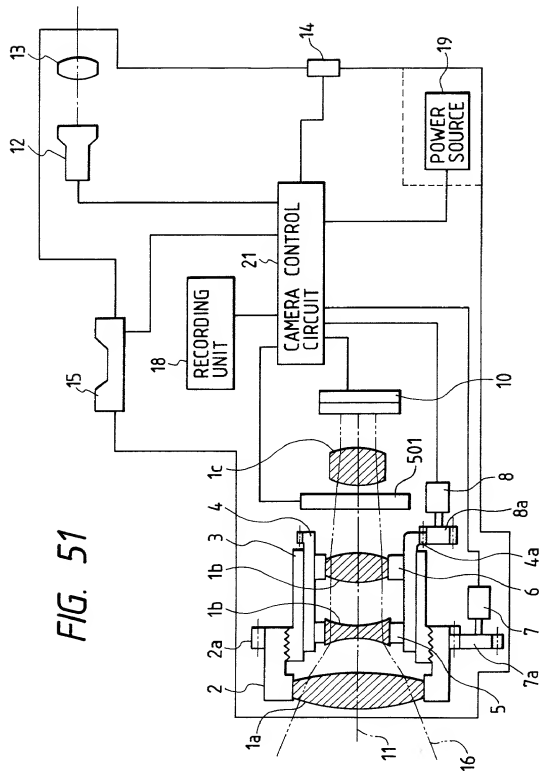


FIG. 52A

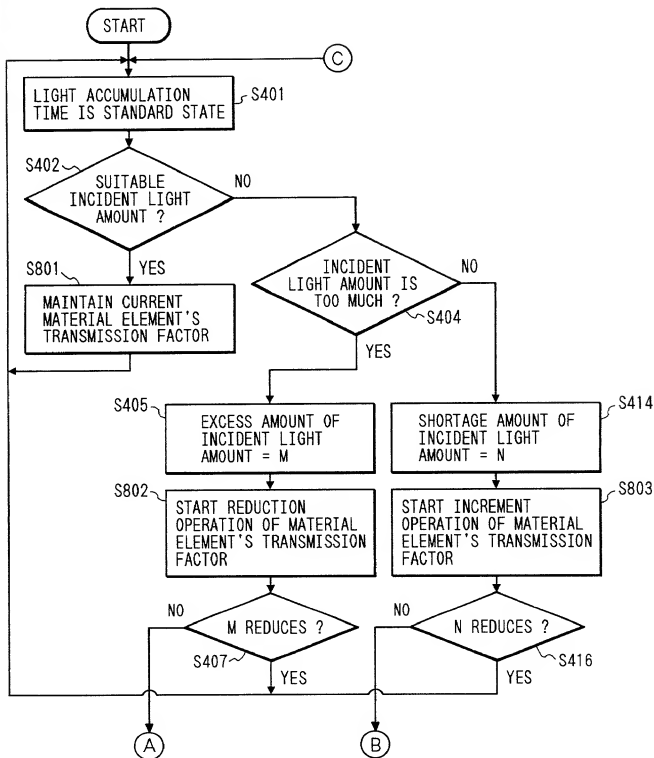


FIG. 52B

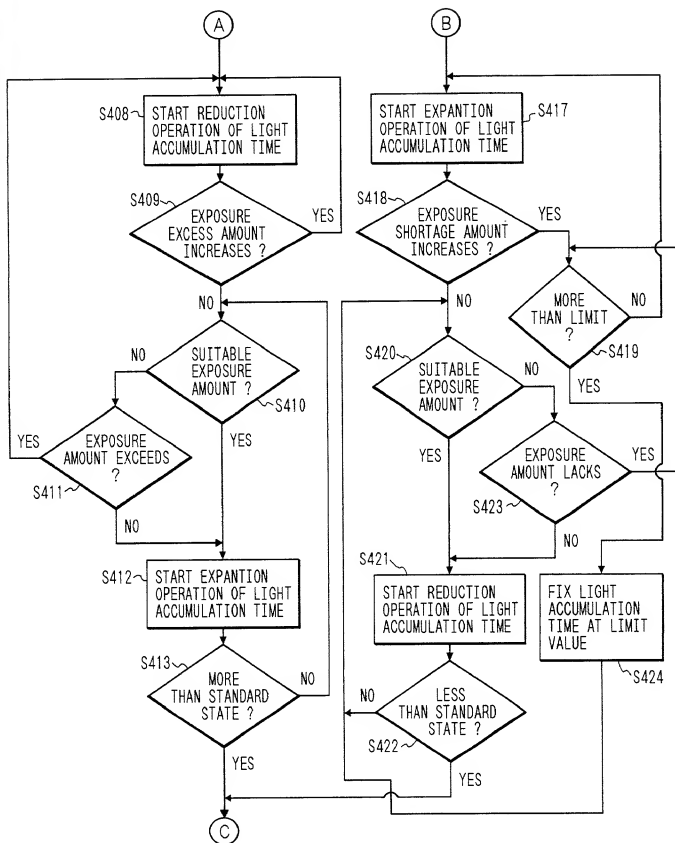


FIG. 53

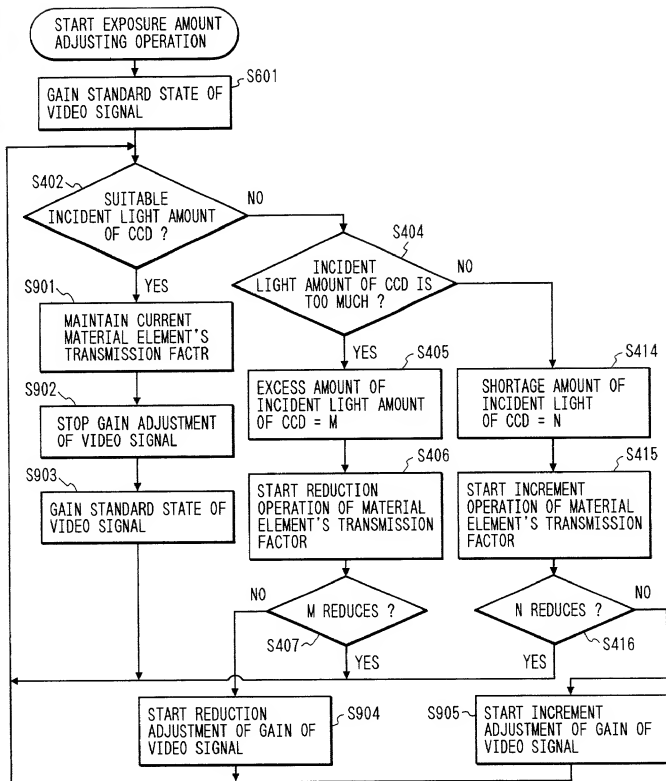


FIG. 54A

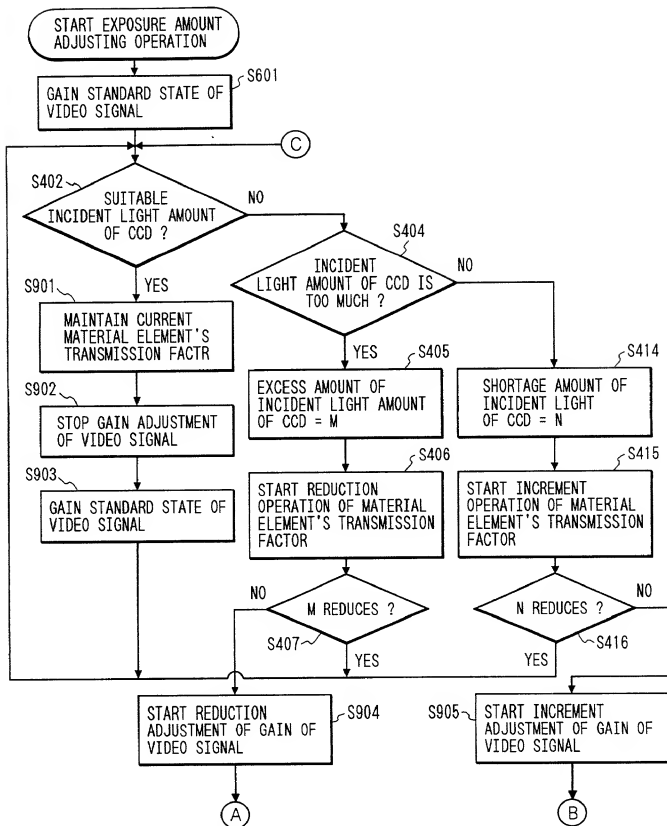
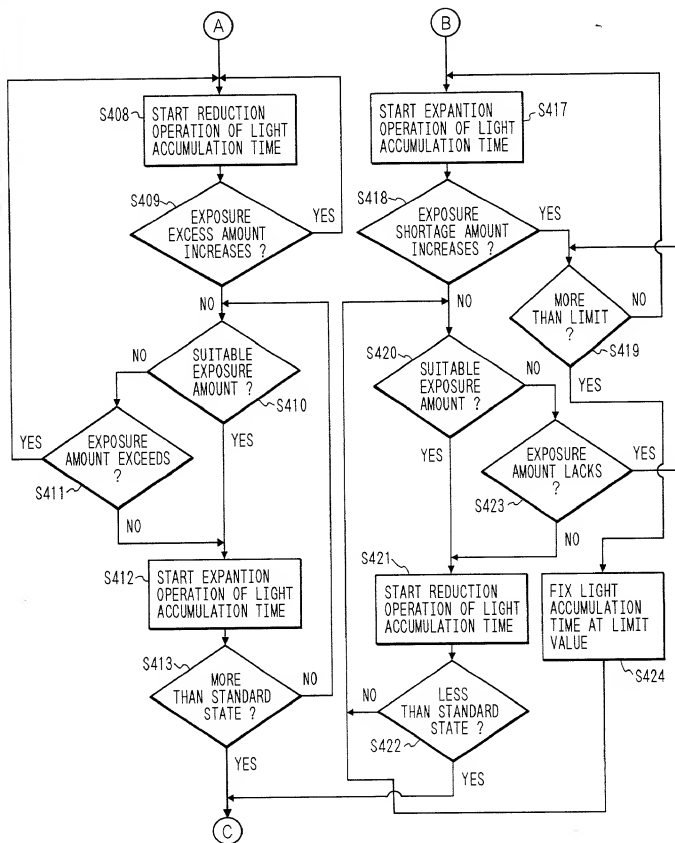
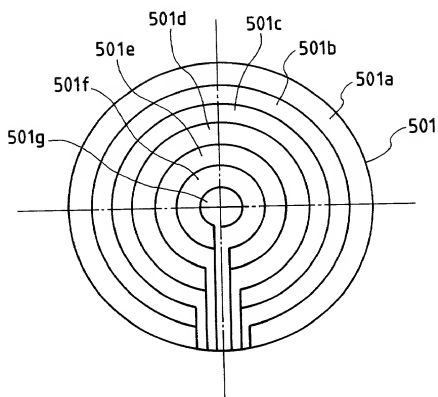


FIG. 54B



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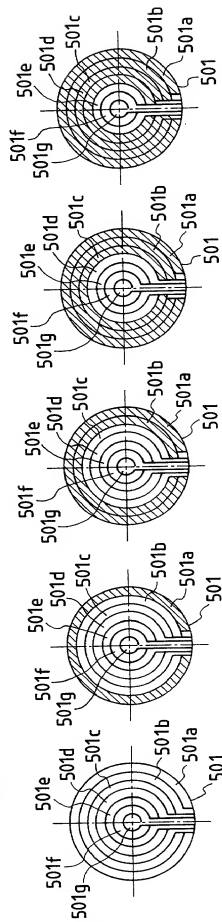
FIG. 55



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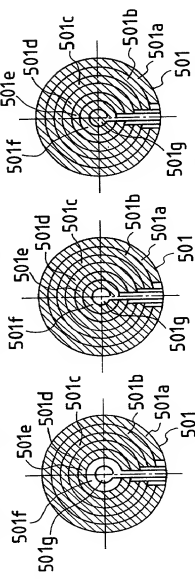
400210-41281-380

FIG. 56A FIG. 56B FIG. 56C FIG. 56D FIG. 56E



LARGE TRANSMISSION FACTOR (DEPTH OF FIELD IS SHALLOW)

FIG. 56F FIG. 56G FIG. 56H



SMALL TRANSMISSION FACTOR
(DEPTH OF FIELD IS DEEP)

170 9371

COMBINED DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name;

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled VIDEO CAMERA

☒ is attached hereto. ☐ was filed on _____, the specification of which _____ as Application

Serial No. _____ and was amended _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Country	Application No.	Filed (Day/Mo./Yr.)	Priority Claimed (Yes/No)
JAPAN	4-216614	23 July 1992	Yes
JAPAN	4-222280	30 July 1992	Yes
JAPAN	4-224340	24 August 1992	Yes
JAPAN	4-247887	17 September 1992	Yes
JAPAN	4-326077	11 November 1992	Yes
JAPAN	Not yet assigned	30 June 1993	Yes

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I hereby appoint Joseph M. Fitzpatrick (Registration No. 17,398), Lawrence F. Scinto (Registration No. 18,973), William J. Brunet (Registration No. 20,452), Robert L. Baechtold (Registration No. 20,860), John A. O'Brien (Registration No. 24,367), Nels T. Lippert (Registration No. 25,888), John A. Krause (Registration No. 24,613), Henry J. Renk (Registration No. 25,499), Peter Saxon (Registration No. 24,947), Anthony M. Zupic (Registration No. 27,276), Charles P. Baker (Registration No. 26,702), Steven J. Bosses (Registration No. 22,291), Edward E. Vassallo (Registration No. 29,117), Ronald A. Clayton (Registration No. 26,718), Lawrence A. Stahl (Registration No. 30,110), Laura A. Bauer (Registration No. 29,767), Leonard P. Diana (Registration No. 29,296), David M. Quinlan (Registration No. 26,641), Nicholas N. Kallas (Registration No. 31,530), William M. Wannisky (Registration No. 28,373), Lawrence Alaburda (Registration No. 31,583), Lawrence S. Perry (Registration No. 31,865), Robert H. Fischer (Registration No. 30,051), Christopher Philip Wrist (Registration No. 32,078), Gary M. Jacobs (Registration No. 28,361), Michael K. O'Neill (Registration No. 32,622), Bruce C. Haas (Registration No. 32,734), Scott K. Reed (Registration No. 32,433), Scott D. Malpede (Registration No. 32,535), John A. Mitchell (Registration No. 19,032), Fredrick M. Zullo (Registration No. 32,452), Richard P. Bauer (Registration No. 31,588), Eric B. Janofsky (Registration No. 30,759), Warren E. Olsen (Registration No. 27,290), Abigail F. Cousins (Registration No. 29,292), Alan W. Fiedler (Registration No. 33,690), Jennifer A. Tegfeldt (Registration No. 31,310), Steven E. Warner (Registration No. 33,326), Thomas J. O'Connell (Registration No. 33,202), Aaron C. Deditch (Registration No. 33,866), Penina Wollman (Registration No. 30,816), David L. Schaeffer (Registration No. 32,716), Jack S. Cubert (Registration No. 24,245), Mark A. Williamson (Registration No. 33,628), John T. Whelan (Registration No. 32,488), Patricia M. Drost (Registration No. 29,790), Jean K. Dudek (Registration No. 30,938), Raymond R. Mandra (Registration No. 34,382) and Dominick A. Conde (Registration No. 33,856), my attorneys to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith.

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**COMBINED DECLARATION AND POWER OF ATTORNEY
FOR PATENT APPLICATION**

(Page 2)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

1-00
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Inventor's signature Masatoshi Nagano
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Residence Ohta-ku, Tokyo, Japan
Post Office Address c/o Canon Kabushiki Kaisha
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Second Inventor's signature _____
Date _____ Citizen/Subject of _____
Residence _____
Post Office Address _____

Full Name of Third Joint Inventor, if any _____
Third Inventor's signature _____
Date _____ Citizen/Subject of _____
Residence _____
Post Office Address _____

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Fourth Inventor's signature _____
Date _____ Citizen/Subject of _____
Residence _____
Post Office Address _____

Full Name of Fifth Joint Inventor, if any _____
Fifth Inventor's signature _____
Date _____ Citizen/Subject of _____
Residence _____
Post Office Address _____

Full Name of Sixth Joint Inventor, if any _____
Sixth Inventor's signature _____
Date _____ Citizen/Subject of _____
Residence _____
Post Office Address _____